THE GEOGRAPHICAL REVIEW

CONTENTS FOR APRIL, 1936

	PAGE
Agrarian Problems in Spain *By E. H. G. Dobby*	177
A View from Canigou: Nature and Man in the Eastern Pyrenees *By Henri Gaussen*	190
The Australian Sand-Ridge Deserts *By C. T. Madigan*	205
The Wood Yukon Expedition of 1935: An Experiment in Photographic Mapping *By Walter A. Wood*	228
The Specialized Commercial Agriculture of the Northern Santa Clara Valley *By Edward N. Torbert*	247
Land-Use and Water-Supply Problems in Southern California: Market Gardens of the Palos Verdes Hills *By H. F. Raup*	264
Meandering Arroyos of the Dry Southwest *By John Leighly*	270
A Geographical Study of New England Temperatures *By P. E. Church*	283
The Future of the Sparsely Populated Rural Towns of Connecticut *By J. L. Hypes*	293
The Changing Sea Level: A Review and Discussion *By Douglas Johnson*	299
A Study of History: A Review *By A. Grenfell Price*	302
Thirty-Second Annual Meeting of the Association of American Geographers	305
American Geographical Society	310
Geographical Record (*listed on the next page*)	319
Geographical Reviews (*listed on the next page*)	339

The Society is not responsible for the opinions or statements of writers in the Review

PUBLISHED QUARTERLY BY THE AMERICAN GEOGRAPHICAL SOCIETY
BROADWAY AT 156TH STREET, NEW YORK, N. Y.

Price, $1.25 a number Five dollars a year

Entered as second-class matter, January 22, 1916, at the Post Office at New York, N. Y., under the Act of August 24, 1912

Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on July 30, 1918

GEOGRAPHICAL RECORD

NORTH AMERICA

Exploration of the Coast Range of British Columbia 319

An Economic and Social Survey of the Southern Appalachians 319

The Poor Agricultural Whites of the South. *By William Van Royen and James M. Reinhardt* 320

Migration in Response to Changing Economic Conditions. *By Allen Belden* 321

Stream Terminology in Maryland 323

The Prairie Peninsula. *By Guy-Harold Smith* 323

SOUTH AMERICA

A Zone of Areism in South America 324

EUROPE

The Exploitation and Colonization of High Peat Bogs in the Netherlands. *By W. Van Royen* 325

The Geography of Settlement in Spain 326

Agrarian Reform in Spain. *By Raymond E. Crist* 327

"Baltic Countries." *By Eugene Van Cleef* 329

POLAR REGIONS

Lincoln Ellsworth's Flight Across West Antarctica 329

Use of Plankton in the Prognostication of Ice. *By I. I. Schell* 332

PHYSICAL GEOGRAPHY

Depths in Small Bays in Relation to Prevailing Winds. *By H. A. Marmer* 332

HUMAN GEOGRAPHY

Trade Boundaries Determined by Traffic Flow. *By Eugene Van Cleef* 333

Recent Developments in the Vegetable Oil Industries 334

METHODOLOGY AND EDUCATIONAL GEOGRAPHY

Geography, the Correlative Science. *By H. J. Fleure* 335

Land-form Regions of Australia 336

Polyglot Dictionaries of Technical Terms 337

GEOGRAPHICAL NEWS

Presentation of the Henry Grier Bryant Gold Medal to President Isaiah Bowman 338

OBITUARY

Count David Costantini 338

GEOGRAPHICAL REVIEWS

C. F. MARBUT. **Atlas of American Agriculture: Part III, Soils of the United States.** *By Charles F. Shaw* 339

ANTON WAGNER. **Los Angeles: Werden, Leben und Gestalt der Zweimillionenstadt in Südkalifornien.** *By H. F. Raup* 341

WALENTY WINID. **Anglja miedzy 1° a 3° dł. Zach. Gr. i 53° a 54° szer. Pn.** *By C. B. Fawcett* 342

HANS SPETHMANN. **Das Ruhrgebiet im Wechselspiel von Land und Leuten, Wirtschaft, Technik und Politik.** *By Richard Hartshorne* 343

J. T. JUTSON. **The Physiography (Geomorphology) of Western Australia.** *By Griffith Taylor* 344

El régimen pluviométrico de la República Argentina. *By Mark Jefferson* 345

WILLIAM S. COOPER. **The History of the Upper Mississippi River in Late Wisconsin and Postglacial Time.** *By Richard Foster Flint* 346

CHARLES KNOWLES BOLTON. **Terra Nova: The Northeast Coast of America before 1602: Annals of Vinland, Markland, Estotiland, Drogeo, Baccalaos, and Norumbega.** *By Halldór Hermannsson* 347

EDGAR PRESTAGE. **The Portuguese Pioneers.** *By George H. T. Kimble* 348

GOMES EANNES DE AZURARA. **Chroniques: La conquête de Ceuta: La découverte de la Guinée.** *By George H. T. Kimble* 348

RICHARD HENNIG. **Die Geographie des homerischen Epos: Eine Studie über die erdkundlichen Elemente der Odyssee.** *By W. A. Heidel* 349

HANS WEINERT. **Die Rassen der Menschheit.** *By Griffith Taylor* 349

Some Problems of Modern Meteorology: A Series of Papers by Various Authors Reprinted from the Quarterly Journal of the Royal Meteorological Society. *By Charles F. Brooks* 350

DAVID BRUNT. **Physical & Dynamical Meteorology.** *By Charles F. Brooks* 350

HARRY T. BENNETT. **The Work of the Mackay Aerial Survey Expedition to Western and South Australia, 1935** 351

THE GEOGRAPHICAL REVIEW

VOL. XXVI | APRIL, 1936 | NO. 2

AGRARIAN PROBLEMS IN SPAIN*

E. H. G. Dobby

THE agrarian question in Spain is commonly associated with the breaking down of enormous estates. Even Spaniards themselves have something of that idea. In fact it is misleading. The Spanish agrarian problem is really a series of problems that differ so sharply from region to region that there seems little possibility of approaching a general solution through the hands of a central government in Madrid. On this discontinuity the plea for a decentralized government and a devolution of certain powers to regional autonomies bases its soundest argument.

GEOGRAPHICAL BACKGROUND

An approach to this complex agrarian position must be backed by a clear understanding of the physical conditions in which the agricultural life is set. The core of Spain is a massive tableland whose average altitude is about 2000 feet. That one fact alone marks off the country from all its neighbors. The high table or Meseta shivers with extreme cold and biting winds in winter and gasps with almost Saharan heat in summer. Much of it is nearly soilless, and in many places old hard rocks show at the surface. The basins of its great rivers are rolling plains of sand and clay that compare in dryness and extreme temperatures with the steppes of Russia. To the north, in the Pyrenees and Cantabrians, lies a broken mountain country resembling Switzerland. To the east, by the Mediterranean, a limestone landscape is a reminder of the Karst. Round the Sierra Nevada in the south are conditions that resemble those in the African Atlas. In Extremadura only a few grasses and oaks can tolerate the denuded schists, and in Galicia, in the extreme northwest, a shattered granite

* The author thanks the Vizconde de Eza and a wide range of informants, from Ministers of State to humble peasants, who generously helped him to view Spanish affairs in proper perspective.

Copyright, 1936, by the American Geographical Society of New York

FIG. 8—Map of the Iberian Peninsula showing humid and arid regions defined by the index of aridity (according to Max. Sorre: Méditerranée. Péninsules méditerranéennes, *Géographie Universelle*, Vol. 7, Pt. 1, 1934, p. 81). The index of aridity permits the influence of temperature to be taken into account in expressing the function of rainfall. De Martonne's formula (described in the *Geogr. Rev.*, Vol. 17, 1927, pp. 403–409) is used: $Ar = P : (T + 10)$, where P is precipitation in mm. and T temperature in degrees C. On the map, close diagonal ruling represents humid areas (Ar above 45), and stipple represents arid areas (Ar below 20). Scale of map 1 : 15,500,000.

mass exhibits certain characteristics of southern Norway with something of the favorable climate of Washington and Oregon.

Relative drought is the pluviometric type over a high percentage of Spain. It has the only large patches in western Europe of country with annual averages of rainfall of less than 15 inches, and parts of Murcia do not receive appreciable rainfall for intervals of five years. In Galicia, where a good 50 inches of rain is the annual average, relative drought still troubles the cultivator because the shallow sandy soils on the granite dry out to a point dangerous for plant life if so few as four days pass without a shower.

Sizes of Agricultural Property

When we wish to examine the distribution of property in Spain, we are faced with an obstacle round which we can get only by inference. Spanish authorities make no clear distinction between "field" and "farm." If a farm is crossed by a path, it becomes registered as two properties. The statistical offices regard the land as the basis of interest and not the individuals who own the land. Thus, one owner may be represented several times in the list of proprietors. Should his property be extensive and divided among several municipalities or several provinces, then no official statement of his whole property can be forthcoming unless each case is taken apart for individual treatment. Complete information about the holdings can only be obtained directly from the owner. Naturally, he will oftenest refuse to divulge the very fact that may, in these days of reform, bring upon him the scourge of expropriation. About 40 per cent of Spain has been covered by a cadastral survey; the rest of the country registers the areas of

properties only at the estimate of the proprietor. Its unreliability can be imagined. For direct taxation, moreover, the tenant is always liable, and so the real proprietor eludes the statistical net once again. Hence, a careful and accurate analysis of Spanish landholdings is impossible.

The Fields

The surveyed part of Spain does not include the areas notable for evenness of land distribution, such as all the northern provinces from Galicia to Catalonia; it covers the zones of large properties and extreme climatic conditions like the Meseta. Most of Andalusia is also surveyed. With this in mind, we may be duly surprised at the figures. The 10 million acres surveyed are divided into 8.5 million fields, which gives an average field somewhat more than an acre in extent. The maximum field acreage is 7 acres, in Cáceres, a province on the shallow-soiled plains west of Madrid, and the minimum one-sixth of an acre, in Soria on the fringe of the Castilian plains. Three-quarters of the surveyed fields are less than half an acre in extent, so that, were the typical small-holdings provinces of the north included, the average for Spain would be much less than half an acre. On the other hand, 18,700 fields were more than 50 acres each and had an average of 230 acres. Thus a curious fragmentation of the land exists side by side with fields of an enormous size. For this fragmentation some method of concentration is urgently needed to make production less interrupted. Probably the soundest scheme yet proposed is to set up local valuation committees to adjudicate the capital value of each man's property and oblige him to accept its value in fewer units of reallotted land. The method would be convenient for central and southern Spain, where people live in the villages away from their farms, but would require special adaptation for the north, where owners live widely scattered on their farms.

The Farms

Only indirectly can we find the figures for ownership of this land. In Seville, many farms are larger than 2500 acres, and one famous farm has 8500 acres. The distribution of estates can be schematically represented by a triangle, with its vertices in Galicia, Catalonia, and Seville. Great landholdings are at their maximum in Seville and decrease along the sides of the triangle to Galicia and Catalonia. Along the north side, the size of properties decreases from Catalonia to Galicia. The average holding in Catalonia may be properly described as normal and reasonable in size for one man to work and maintain his family from the produce. In Galicia the fragmentation of property is too great, and the average holding there is less than what is necessary

for maintaining a family: the problem is one of uniform poverty arising from an average deficiency of land.

Rural Social Questions in Central and Southern Spain

On the Meseta and to the south, the land problem is the one common to countries that have recently had a semifeudal outlook—the problem of breaking down large estates and redistributing the land more equitably. These parts of Spain sharply focus their social grievances. The people dwell in large villages or towns of 18,000 to 20,000 inhabitants, where the distress of seasonal labor demands is visibly concentrated. The landless poor are always close to starvation standards; corporate assistance for them is unknown, and with the severe climate and "town" life not even the garden patch softens the effects of rural poverty as it does in countries of milder climate and smaller villages. It is impossible for anyone who has not lived through the glum despair of unemployment in these scattered agricultural towns of Spain to imagine the dark atmosphere and abject poverty of the regular workless seasons.

A limited range of crops gives rise to intense seasonal occupation. If it in turn creates high wage rates for the "rush" season, the wage in no wise suffices to carry over a family to the next peak season. For this limited economy the owners of the large estates have been to a large measure responsible. Only now, after long years of social trouble and anarchy, is any serious attempt being made to seek greater range of crops. Whether the rural laborer has been wise in the method of making felt his terrible social condition may be questioned; but at any rate we must sympathize with his circumstances.

I recall an incident during a visit to an experimental pig farm in an out-of-the-way part of Andalusia. From the darkness at one end of the building came a red glow. I went along and found a laborer's family crouched on the floor round a twig fire with smoke so thick that breathing was difficult. The malodorous squalor contrasted with the carefully washed sties that I had been seeing. To my query an old woman mumbled: "Yes, we live here. Worse than the pigs." At which the owner beside me exclaimed indignantly: "You have a roof over your head. What more do you want?"

An added exasperation is that the seasonal demand may require importation of labor from far provinces, which gives rise to the anomaly that, in an area noted for rural unemployment, migrant labor must be called in. The three crops of Andalusia—cereals, olives, and vines—give some spread of labor; but in Castile wheat and barley are the only crops, and even these vary enormously in yield according to the variations of rainfall. The plight of the rural laborer, then, is pitiable and that of a small holder little less.

Extreme concentration of population creates in itself another problem. Many of the large agricultural towns are 35 miles apart, and in parts of the Meseta one may travel by horse for a couple of days and not meet a human being. This implies a waste of working time in journeys to the fields; and when laborers live for a fortnight or so in one of the lonely shelters, home ties are disrupted, since the family remains in the "village." Spain needs to be colonized internally to bring countrymen nearer the land they work.

The legal limit above which farms are considered "large estates" is 25 acres. But this figure must be viewed with an understanding of the type of country involved. Two-fifths of Spain is capable of supporting barely two sheep a year to an acre. To divide that land into small holdings would be madness. Even the cereal plains have a special nature: one-tenth of the area may be called "intensive" cereal land, supporting a constant rotation of wheat and beans; one-seventh can be sown only in alternate years, with an intervening year of unproductive plowing; two-fifths are cultivable on the basis one year wheat, one year under spontaneous grasses for grazing sheep, one year for plowing without any crop; a quarter is used in the most primitive system imaginable—a year of plowing, a crop of cereals, and abandonment for six to ten years.

In the Northwest

At the northwestern extreme of the peninsula, in Galicia and Asturias, the land is minutely divided. Weather is less severe, and rainfall is less markedly seasonal; the growing season is so long that in Pontevedra, for example, trees defy normal botanical laws and put on two rings a year, and vegetables can be grown nearly the year round. On the other hand, the soil is poor. It is estimated that, including the moors of high relief and exposure, not more than one-fifth of the northwest is permanently productive. Neglected for generations, Galicia remained isolated from the rest of Spain. Yet, the province carries a greater density of population than the rest of the country. To own two acres and two cows is to be considered a man of means. Holdings, besides being small, are so scattered that patches of tilled land less than fifty square yards in area are common; fragmentation is so marked that in the especially mild valleys of Pontevedra the fields are of hardly more than pocket-handkerchief size. Hundreds of owners of these tiny properties move to Castile for the reaping season in July: previously yearly migrations were made to Argentina, Cuba, and Brazil, but now all these outlets abroad are closed.

This excessive subdivision in Galicia is entirely a modern phase; in the mid-nineteenth century great estates were as common there as in Castile and Andalusia. When the South American countries were

rapidly opening up in the fifty years before the World War, emigrant Gallegos had their great chance, and from it they made enough money to buy pieces of the estates. Thus was brought about a natural redistribution of the land. The pressure upon the land has been enormous; returned emigrants have paid fantastic prices, prices beyond any hope of economic return and based more on personal pride than on anything else. Great seignorial houses, *los pazos*, are abandoned; they no longer have estates large enough to maintain them. The character of Galician rural economy now is its self-sufficiency. There are no commercial crops. What is produced is normally eaten by the owner and his family; until the last few years, even clothes were homemade on the same principle. When money becomes necessary, then appears the flaw. There are no ready markets for the produce of the province, and, even if there were, it would be inviting starvation to sell what the family needs for its own simple life. To pay taxes, a calf will be sold to a Catalan butcher: that is an economic mistake. Galicia developed to efficiency would be a cattle-rearing province; it has ample moist pastures and should subdue all agriculture to that end, abandoning the sowing of those cereals that cost more to produce there than in Castile. The future for Galicia is in its animals. Yet now, the small homesteads rarely possess more than one cow each; this animal must work the fields, breed every year, and give milk for the cheese that is a staple in Galician diet. How the Galician cow maintains what few qualities it has is a mystery.

Catalonia and Murcia

Catalonia may be called the province of ideally distributed land, and the structure of agriculture there shows a harmony between production for home consumption and production for commerce. Wide climatic extremes with concomitant fluctuations of crops do not occur. Land is worked as intensely as any dry-farming area can be worked: in fact, Catalans are said to produce "bread from stones" because they obtain so much from conditions that, although amenable, are not favorable. Great landowners, again, are nearly unknown, and the letting of land is done by small-propertied men who have just too much land to be workable by their own families. Laborers at wages are rarely employed, and the main Catalan problem is that of reframing the classic contract to plant vines. Pressure upon the land does not reach a critical point as in Galicia, because the industrial centers around Barcelona absorb both capital and labor from the country.

A contrast is found in Murcia, where the complex problem of seasonal labor, common to all south and central Spain, is accentuated by an extreme drought that often makes it difficult to find water for domestic use. Only the alluvial fans and valley bottoms are cultivable,

so that, when the rare and torrential rains do come, they send floods rushing through the valleys, ruining the carefully nursed crops and scattering devastation everywhere. Life depends on a balance between a year of fat crops and three or four following years when rain is not enough for so much as an average crop of wheat.

Diverse Systems of Land Tenure

Much harm has arisen from that distrust of banks that comes of simple people's living in isolated places where political graft has been an accepted custom. In the past, when a little money was made, it was spent in the purchase of new land. Few realized that money got out of land may be best reinvested in the same land, to maintain if not to improve its qualities. Today the position is not less unfortunately reversed. With agrarian reform discussed on all sides, those having money distrust land as an investment and put their money in the banks. The effect of both extremes is the same—neglect to improve the quality of rural Spain.

The Spanish systems of land tenure, of many different types, bear heavily on the general framework of the agrarian question. The commonest type of tenure in Spain is known as *aparceria a medias*. Land is handed over to a laborer who agrees to work it and share the fruits—and the incidental expenses—with the landowner. If the laborer cannot bear his part of the expenses, the owner agrees to pay them, with an adjustment of the produce in his favor. In the north, even animals are let out in herds on the same basis. This system has many points in its favor: but it is such that the owner always gains something, whereas the laborer may get no return should the risk of weather go against him; he is liable, in addition, for the fixed land taxes on his borrowed land. The owner has the labor question solved without incurring any wage bill. The *aparceria* system depends on confidence between laborer and owner, since both consult together at critical points in cultivation and decide between them what crops shall be put in. Often the contract is purely oral and has continued without change for generations in the same family of laborers. It is handed from father to son as if it were the laborer's own property. In unsurveyed areas many cases arise in which the laborer passes to his son information about the exact limits of an estate of which the landowner himself may not know the landmarks nor have them stated in his deeds.

In Catalonia a special form of *aparceria* has created an agrarian backing to the Catalan question and the claim to regional autonomy. When Campanys, the former president of Catalonia, while broadcasting in October, 1934, was arrested for complicity in the revolution, he cried into the microphone: "A mi, los rabasaires, a mi! (To me, you *rabasaires*, to me!)," thus calling to his aid the group of discontents

especially affected by the *aparceria* system. The *rabasaires* are tenants who receive land upon which they contract to plant vines on the basis that costs and fruits are shared equally with the owner. This contract binds both parties until three-quarters of the planted vines shall die (*rabasa morte*), when the land reverts to the owner at his option to renew the contract if he thinks fit. In this period of duration the Catalan system differs from the normal Spanish custom and is the crux of the problem. In the last century, before the phylloxera plague laid waste the vineyards and brought a revolution in vine technique, the life of a vine was about fifty years. That assured the laborer a long contract that would practically cover his life and adequately remunerate him for the six or eight years of fruitless labor that young vines require before they mature.

Since that plague, new types of vines have had to be introduced, which have only some twenty-five years of productive life. They require a sustained labor, a series of complicated precautions against disease, and an elaborate technique that were unknown before. The assertion is, then, that the old basis of contract does not give return for the labor put in during the early fruitless years of the plant. When the first of the new contracts terminated during the war years, no trouble occurred over this point because prices were high enough to be profitable to the laborer. Now that wine prices are falling and symptoms of glut appear on every side, the unprofitable term of contract is brought to the front very clearly. For this reason the *rabasaires* play a large part in the left-wing politics of rural Catalonia. An attempt to solve this problem by a Catalan land-tenure bill, drawn up by Campanys' regional government, was rejected by the central government in Madrid, and thus was precipitated the serious trouble in Barcelona during October, 1934.

In Galicia the *foro* system formerly held sway. The *foro* was a type of lease that originally had a nominal fixed rent in kind. With the lapse of years, subletting occurred, through as many as ten intermediate hands, and finally made the rent charge out of proportion to the natural yield of the ground. The system was not unlike the English tithe and bore down heavily upon the agriculturist. This uneconomic rent was one of the causes contributory to temporary emigration from the province as soon as labor was in demand elsewhere. Most of the evils of the system have now been smoothed away by redemption.

Extremadura has an unusual form of land tenure, which became the root of social disturbances that centered about Alburquerque in the province of Badajoz. In that region great stretches of schist carry a poor, thin soil, upon which small, gnarled oaks grow in open formation. Short grasses of pronounced seasonal character struggle on the dry plains. It has become the custom to plow between the trees and

get a wheat or barley crop once in about twelve years, a catch crop that immediately exhausts the earth. Thence arise four economic aspects of production: pig feeding on the acorns that fall in the autumn; sheep grazing upon the thin winter grasses; charcoal making from the year's timber; and the long-interval cereal crop. The land question is complicated because these four rights may be held by four different people, and the peasants maintain that the grazing of the land when not in cereals is a communal right: often they deny even the right of any private individual to own a piece of such land. This is the crux of the *baldios* problem in Cáceres and Badajoz—a problem that is an anachronistic relic of conflict between nomadic cattlemen and agriculturists.

It is regrettable that this country, originally noted for its sheep, should show only a small increase in the number maintained. Goats have increased three times as much as sheep, with consequent ill effects on shrub vegetation. Not for nothing is the goat called the rat and scourge of the plains.

Wheat in Spanish Rural Economy

The structure of Spanish rural economy can be understood at once from two facts: half of the area is uncultivated, rough steppe-pasture of a type not found elsewhere in western Europe; two-thirds of the cultivated area is sown with wheat and barley. The importance of wheat stands out at once. Spanish production of wheat to a unit area is almost the smallest in Europe (13.4 bushels per acre against 33 for the United Kingdom, 1924–1933), and this suggests that the main problem is to augment the yield. Although to some extent this may be true, it must be remembered that the Spanish conditions of climate and altitude find no counterpart in Central Europe: the crop of cereals is more closely bound to the vagaries of unreliable weather than anywhere else in the continent. Yet, if the yield of wheat in northern Spain, where physical conditions are "European," is compared with that in other European countries, it is found to be second only to the average German yield. If we remember that nearly the whole province of Cuenca has an average rainfall of less than ten inches a year, we understand that no amount of mechanization will alter the fundamental defect of climate.

Uneconomic Marginal Lands

The effect of the World War in rural Spain was to raise prices to a phenomenal figure that put large areas of new land under cultivation, much of it land that had better been left as pasture or open shrub forest. The newly planted area gave a few years of reasonable crops and then had to be completely abandoned or subsidized because the

yield was not in proportion to the cost of exploitation. When abandoned it had less value than before. Spontaneous vegetation reasserts itself slowly under the extreme climate of Castile: sheep were without grazing, and the soil, unconsolidated by roots, was exposed to the dangers of erosion. That land that remained in cultivation could do so only behind a protection, *la tasa*. The *tasa* prohibits all imports of wheat at less than a stated price. This served to maintain the internal price of wheat in Spain at nearly one-third above the external market value and kept bread at a level that called for high wages and created difficulties with the exports of Spanish products when contingents became an international policy. Cereals are produced at high labor costs: the wages are not high, but the amount of labor used is enormous. That is why Spain depends for success in cereal cultivation on the production by fair-sized owner-farmers who put in a large amount of work without having a high wage bill.

Mechanization

Upon the large cereal farms of Castile and Andalusia mechanized methods could be used; the farmers themselves realize the necessity for them and have mechanical threshers and reapers. Yet these machines go unused, partly because the Socialist government of the early Republic definitely prohibited them, and partly because the displaced labor would aggravate a rural unemployment that already bristles with unpleasant social conflicts. The *tasa*, a bar on imported cereals, operates to keep uneconomic lands in cultivation, yet some vague-minded Spanish politicians still call for greater cultivation of wheat. Present production roughly balances internal consumption; to enter the export trade is impossible with the price of Spanish wheat above that of wheat from the newer countries. *El Norte de Castilla*, the Valladolid paper, recently exclaimed: "More land in wheat? *Por Dios!* No. Less land, better yield, and lower costs."

Reafforestation

Spain is a classic example of the ill effects of reckless deforestation. The desolate mountains and treeless plains of the Meseta appall the stranger who passes through them. Now, with the originally thin soil removed by torrential rain and with piercing cold winds sweeping unbroken across the land, reafforestation can be accomplished only with difficulty. When well established, trees are comparatively indifferent to variations of weather, and tree crops give an element of constancy to rural economy. Hence the eastern fringe of the Meseta, from Catalonia to the Levante, has developed fruit and trees as characteristic parts of the agriculture. Andalusia successfully makes the olive its mainstay and is rapidly increasing its area under olives.

The rocky mass of Salamanca, Cáceres, and Badajoz, likewise finds constancy in the oak forests, where pigs can be raised on the acorns. These examples indicate how the erratic booms and slumps of the Castiles may be moderated by planting trees if only the government will persevere with experiment and finance to overcome the initial obstacles. One of the difficulties that arise in present circumstances is that saline deposits have asserted themselves on the surface where a close vegetation cover has been long absent. This matter is so serious that in one case, where five thousand trees were planted in La Mancha, sheltered by screens during the winter and watered by hand during the first summers, only twenty-five remained after five years.

Coöperation

Yet another of the Spanish problems is coöperation. At present the most efficient farms are the large ones where the owner, having some resources, can watch markets for the best opportunity to sell and can effect some standardization of his produce. The small Spanish farmer is completely at the mercy of intermediaries. The Galician sells his one calf a year and gets nothing like its value; cheeses from the Cantabrians suffer from lack of standardization in quality and no promotion of the internal markets; olive growers of the south still mill olives in rough, old-fashioned ways and sell the oil at a disadvantage because dealers must refine it; orange growers of Valencia send their products to the buyer ungraded, and unscrupulous packing has undermined their market reputation, so that in face of the competition of newer orange countries the Spanish orange loses ground; and Spanish wines are produced in small cellars, so that "controlled mark" and standard qualities are almost unknown. Spanish wines are regularly bought up by French dealers, "worked" to French standards, and sold to the world as French wines. All these defects arise from disunity among the producers. They have been content with "snatched" markets in the past, and now, when their products must compete with those of countries that have studied market conditions, they are left with markets falling from them on all sides.

Only in Catalonia are there a few coöperative wine cellars. Some vague attempts at coöperation are being made among the dairy farmers in the Santander district. Pressure of lowering prices and high labor costs make unity in marketing the *sine qua non*. Why coöperative movements have not appeared in Spain is not difficult to analyze. Many country folk cannot read and are keenly suspicious of what goes on just beyond them; distance isolates the people and causes distrust of strangers; the cultured classes show no coöperative effort among themselves as an example; political instability has created distrust of credit and of any form of payment that is not spot

cash; the organizing and intelligent class has constantly fled from the country to the ease of some government sinecure; and the low salaries paid to officials have led to corruption and bribery. The energetic efforts of the Republic in its early years to stamp out the atmosphere of graft in Spanish public life deserve the utmost praise.

Agrarian Reform under the Republic

We must finally examine the results of that zeal for agrarian reform that began the new republic. Unfortunately, the enthusiastic and well intentioned legislators who drew up the agrarian laws were without intimate knowledge of the land; they held before themselves the types of reform that had been tried in other countries, and they failed to realize the special character or the range of Spanish problems. The agrarian reform laws were directed almost exclusively to the question of large estates. Thus the Instituto de Reforma Agraria, which is an independent body set up by the Cortes to administer and control agrarian reforms, was given no jurisdiction in the northern sector of Spain because it had no large estates.

Behind the new laws was the doctrine that "those who work the land should own it." Unfortunately, that formula is not likely to solve many Spanish difficulties. In the early impressionable days it would have been better to insist on the responsibility as agents of the state of all who possessed or worked the land. The state, after all, can only initiate and promote movements; society has to carry the work to its completed end. In any case, to shatter confidence in land values by legalizing confiscation was not wise in an agricultural country unless some clear-cut, energetic land scheme was to be put rapidly into action. It was bad luck for Azaña's government that this energetic scheme did not materialize because at the critical stages the whole agricultural structure broke. By an unfortunate coincidence the world crisis came just at that time to cut off all the markets on which Spanish agriculture was based. As a result of this influence over which the government had no control, agrarian matters have gone from bad to worse. Small holders who never were in real danger of expropriation began to distrust and to deplore the reforms.

With 300,000 acres of land confiscated in the first two years, little progress has been made. By the end of 1934, only about 8000 acres had been redistributed and some 2000 families settled upon small holdings. These families were given the option to work on communal lines, but all chose to receive individual holdings. They work under the supervision of government advisers and will become full owners of the land after fifteen annual payments to the state. They are provided with mules and supplies to start with and are expected to use no labor beyond that of the family. Considerable

attention has been given to experiments in widening the range of crops produced and particularly to the growing of cotton in Andalusia, where conditions are favorable if only the labor can be suitably adapted.

Irrigation Schemes

Besides this body that works for reform, considerable importance attaches to the *confederaciónes hidraulicas* that were set up under Primo de Rivera in his effort to decentralize administration. These *confederaciónes* are groups of technicians who prepare plans for irrigation and water power in conjunction with representatives from agriculturists, industrialists, and private interests in general. There is one *confederación* for each of the river basins with the object of coördinating on the broadest possible basis the whole range of interests in controlling the waters of the arterial rivers. The Confederación del Ebro has made greater progress than the others so far and has changed for the better the agricultural outlook of Aragon. With these organizations there is every prospect of intensifying much of the agriculture, removing direct dependence on the weather, and at the same time creating an effective service of rural electricity. The *confederaciónes* likewise undertake to instruct the farmers in the technique of irrigation, which has previously been unknown to them. They also plan for the necessary means of communication to bring products of irrigated lands to the right market, a part of Spanish rural economy that has been sadly neglected. Unfortunately, the admirable plans of these groups are jeopardized by political changes, since a scheme approved by one government will probably be jettisoned by the next before the scheme comes into effect, or, having become effective, it will find itself with financial backing cut from it.

Conclusion

In short, the range of agrarian problems in Spain is greater than that confronting most states. These problems, accumulated from centuries without directed effort, are aggravated by a complex of difficult physical circumstances and a series of anachronisms in land laws. Public confidence has repeatedly been shaken by bad government, and any sense of social coöperation has been completely lost. The remedies are obvious to those who squarely confront the problems, but they can be efficacious only when a soundly constructed scheme to embrace the whole perspective of Spanish agrarian difficulties is unremittingly pursued over a considerable period of years.

A VIEW FROM CANIGOU

NATURE AND MAN IN THE EASTERN PYRENEES

Henri Gaussen
University of Toulouse

FIG. 1

Muntanyes regalades — Coronades de plata
Son les del Canigo — Y vestides de flors.

"Happy mountains are the mountains of Canigou, crowned with silver, decked with flowers," runs the famous Catalan song. And in truth Canigou enthroned in majesty 9000 feet above the plain is a sight to inspire song and a benefactor to inspire gratitude. From its commanding summit, snow-capped the greater part of the year, one may look across the flowery meadows, the ridges and valleys, and the fertile fields of the plains to the blue Mediterranean. It is a good place from which to view the relations between nature and man in the eastern Pyrenees.

THE DIVERSITY OF THE EASTERN PYRENEES

The eastern Pyrenees are the most diversified part of a mountain chain that, for all the modesty of its dimensions, is notable for diversity—of rocks, soils, climate, and vegetation.[1] With but a single break (Middle Jurassic to Upper Cretaceous) the entire sequence of the geological record is represented in the Pyrenees. Soils are found in various stages of transformation from skeletal to climatic types. Climates range from the semideserts of the Upper Ebro with a rainfall of less than 8 inches a year to the humid Atlantic borders with 80 inches of rain on the seaward slopes and mountain climates with

[1] On the region in general see Maximilien Sorre: Les Pyrénées méditerranéennes: Étude de géographie biologique, Paris, 1913 (important bibliography); the same: Les Pyrénées (Collection Armand Colin, No. 15), Paris, 1922; Henri Gaussen: Végétation de la moitié orientale des Pyrénées: Sol, climat, végétation (Documents pour la carte des productions végétales, Ser.: Pyrénées: Généralités, Vol. 1), Paris, 1926 (important bibliography); the same: Géographie botanique et agricole des Pyrénées orientales (*ibid.*, Ser.: Pyrénées: Roussillon, Vol. 1), Paris, 1934 (important bibliography); and Pau Vila: Resum de geografia de Catalunya (Colleccio popular Barcino, Nos. 43, 47, 58, 60, 69, 108, 109, 113, 115) Barcelona, 1928–1931.

120 inches; and absolute extremes of temperature range from – 30.6° F. (January, 1891) on the peak of Midi de Bigorre (8780 feet) to 109.7° F. (June, 1882) at Toulouse and 113° F. (July, 1880) at Zaragoza. The flora, exposed to the vicissitudes to which these Mediterranean countries have been subjected, has known the invasions of elements from Central Europe and from the Arctic and even, during the interglacials,

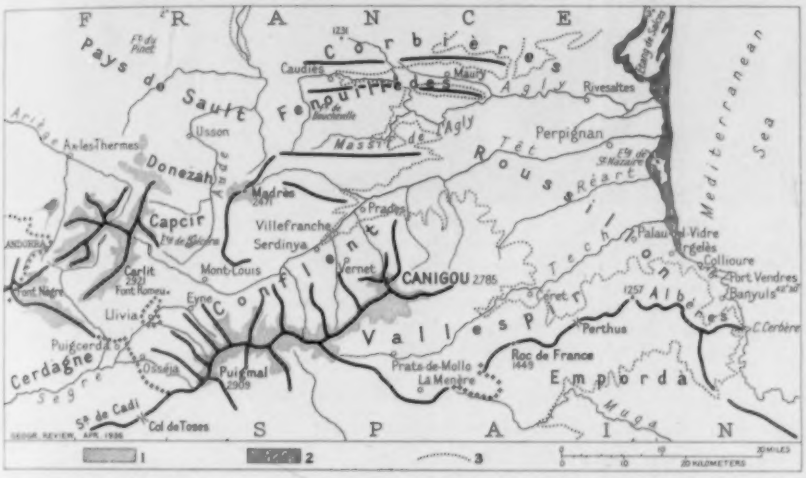


FIG. 2—Map of the eastern Pyrenees showing the main mountain axes and the natural regions. Key to the legend: 1, alpine zone; 2, saline lands of the coast; 3, limits of the olive. Scale 1 : 1,200,000.

from eastern Europe. The vegetation, reflecting the nuances of soil, climate, and floristic influence, is extraordinary in its variety, especially by reason of the innumerable microclimates. In the eastern part of the chain, with which we are here concerned, diversity is increased by the circumstance that the Holarctic and Mediterranean floristic regions meet here. Mt. Canigou (2785 meters or 9136 feet), although not the highest elevation of the eastern Pyrenees, is the best known and offers peculiar advantages for our prospective view.

THE NATURAL REGIONS

The schematic map, Figure 2, reveals Canigou as the termination of the long chain of Cadi-Puigmal, which, although composed of disparate geological and tectonic elements, has a distinct geographical unity. A secondary chain to the south comprising the Roc de France and the Albères continues the frontier eastward to the Mediterranean. Westward the limit of our area is defined by the massif of Carlit. Between Carlit and Cadi-Canigou is the plateau of Cerdagne, generally considered a tectonic basin. Between the Carlit and Madres massifs is a similar basin, the high plateau of Capcir. Between the Albères and the northernmost folds of the Pyrenean system, the Corbières, is

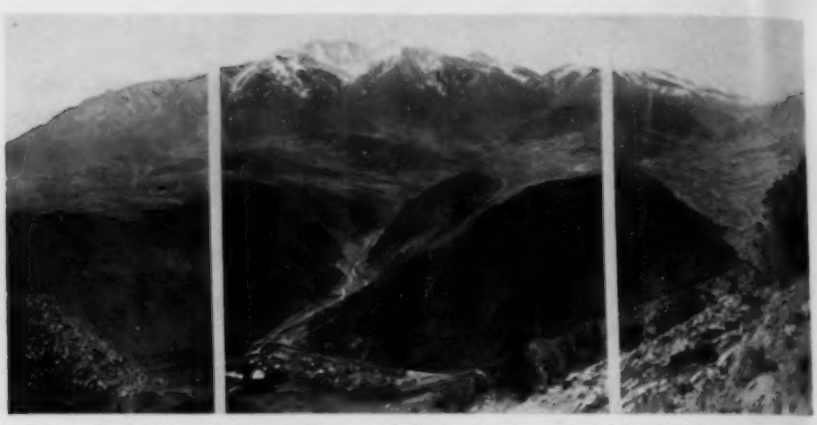


FIG. 3—Canigou from the Roques-Rouges. TheRoches-Rouges on the left bank of the Tet overlook Villefranche-de-Conflent, whose fortress and walls are seen in the foreground. The Tet flows from right to left. The view gives directly onto the valley of Vernet-les-Bains, with irrigation canal winding along the valley sides and water from the Tet carried across the valley by siphon. The plateau pedestal from which Canigou rises is devoted to orchard-meadows. Destruction of the forest mantle on Canigou is apparent. Mountain pine occupies the crests with little snow; the alpine pastures above are snow free in summer except for some permanent snow banks.

the plain of Roussillon, another tectonic depression. In Pliocene time the sea washed the foot of Canigou. Alluvium from the coast streams of the Agly, the Têt, and the Tech, filled the gulf and with the aid of a pronounced movement of emergence created the plain. It is still poorly drained, and the shore is bordered by brackish lagoons.

THE LANDSCAPE BEFORE MAN'S ARRIVAL

For our understanding of present-day conditions about Canigou we must follow the vicissitudes of the country from the end of the Pliocene. At that time the plain of Roussillon, as has been said above,

FIG. 4—The peat bog of Pinet, on the plateau of Sault. Springs and an impermeable soil have permitted the survival of this bog from the Glacial period, and its mountain pines at an altitude of 800 meters are a glacial relict.

did not exist. We have some hints as to the appearance of the country. Fossil remains of vegetation at an elevation of 1200 meters in Cerdagne, include beech, oak, maple, *Zelkova*, lime, birch, fir, sweet chestnut. They belong to the beginning of the Pliocene, and they suggest a forest physiognomy similar to that of the Appalachians. The forest flora was evidently richer than that of today, and what is true of Cerdagne is doubtless true of other parts of the eastern Pyrenees.

The Glacial age arrived. Carlit and Puigmal bear traces of the great glaciers that descended to Cerdagne. Following the generally accepted figures, without qualification as to dates and details, we may suppose the limits of vegetation to have been lowered 700 meters.

Today on the flanks of Canigou the altitudinal zones of vegetation, local conditions being disregarded, may be summarized thus:

Eumediterranean: holm oak, cork oak, and olive up to 400 meters
Submediterranean: holm oak and Corsican pine (v. Salzmanni) from 400 to 1000 meters
Oak and other hardwoods from 600 to 1300 meters
Mountain zone: beech, Scotch fir, and fir from 1200 to 1800 meters
Subalpine zone: mountain pine from 1600 to 2300 meters
Alpine zone: without trees above 2300 meters

On the basis of zones similar to those of today the sequence in Glacial times would be thus:

Eumediterranean, absent
Submediterranean up to 300 meters
Oaks and other hardwoods up to 600 meters
Mountain zone up to 1100 meters
Subalpine up to 1700 meters
Alpine above 1700 meters

Sheltered conditions locally permitted the survival of the Eumediterranean flora. The cork oak took refuge in the recesses of the Albères, with siliceous soils; the lime-loving plants found a haven on the Corbières or in the Conflent, as near Villefranche.

With the retreat of the glaciers vegetational limits rose anew. The ice, however, left some traces. Along the riverbanks a relatively cool environment furnished a habitat for plants that had descended to these levels during the glaciations. It is even probable that, but for the action of man, cooler-climate woods forming a closed community might have survived in spite of the warmer postglacial. Examples are known from the Pyrenees and Languedoc. One of the most striking is that of a wood of mountain pine, a subalpine tree, thriving at 800 meters in the Pinet peat bog (Fig. 4). But presumably during the dry periods man established himself in such places and with few exceptions destroyed them.

That the climate following the last glaciation was warmer and drier (xerothermic) than that of the present seems to have been demon-

strated beyond a doubt. Consideration of the routes of species across the passes and the evidences of erosion suggest that the vegetational zones were 300 or 400 meters higher than they are at present. Later the climate suffered a sensible cooling coincidently with the growth of the peat bogs and the invasion of the beech into southwestern Europe. This cooling inaugurated the mesohygrothermic period that continues to the present.

Thus a picture of the vegetation of today as it would have been but for man's intervention includes:

1. An essentially forest vegetation disposed in altitudinal zones according to the floristic resources of the region. (Altitude and composition indicated above.)

2. Relicts of the Glacial epoch preserved along the watercourses, about springs, and in the peat bogs.

3. Xerothermic survivors preserved in dry microclimates.

With the exception of the alpine zone, treeless by definition, the saline lands and perhaps some sandy patches, and rocks too precipitous or too dry, the country must have been completely forested. Hardwoods would have been dominant up to the upper limit of the mountain zone, with the Scotch fir and the Corsican pine in dry and rocky areas not accepted by other trees.

The Action of Man

It is certain that man has lived in the Pyrenees since the end of the Ice Age, though we still cannot say much concerning the results of his occupation. If he was numerous enough and if he engaged in pastoral pursuits, he may have cleared the forest in parts freed from the ice. This may have happened in certain parts of Cerdagne, but it is of little more than speculative interest. Our concern is with the known changes, and these we can best study by taking up the several natural regions in succession.

The Flat Coast

This region of sandy, saline, or marshy lands offers few resources save fishing, and as a whole man has scarcely touched it. By drainage and by special cultural practices the most favorable parts have been transformed into vineyards and thus belong in the plain of Roussillon. An experiment in afforestation is a wood of cluster pine planted at Argelès-sur-Mer. Accumulations of organic detritus in the ponds are gathered as fertilizer for the sandy lands.

The Plain of Roussillon

Man has completely transformed the plain of Roussillon. But for him there would reign over it a forest of holm oak with a mixture of

white oak, willow, poplar, alder, and Provençal cane (giant reed) along the watercourses. The xerothermic period perhaps did not permit a continuous forest cover, and fire and cattle without doubt made demands on the forests. In due course pasturages and cultivations took their place. The ancient existence of forests is proved by both historical documents and the existing remnants. A country open to the passage of migrants and armies, the plain of Roussillon has known dark days in its history and depopulations, but each time that peace has held sway its prosperity has risen anew.

Large rivers bring down water from the mountains, and man long since learned the value of irrigation in a dry climate; whence there are two distinct divisions in Roussillon: the irrigated lands or *regatiu* and the nonirrigated or *aspre*. With the *regatiu* are included the river-banks, where humidity of the soil permits survival of the glacial relicts and plants of the deciduous-tree zone. In some places natural meadows occupy the damper soil. Man has made the most of the best alluvial lands along the rivers; he has manured them heavily and in places has established a peculiar cultivation, that of the nettle tree. This tree has an enormous annual growth, as much as three centimeters in thickness. The wood of the nettle tree when treated (in a vapor bath) is extraordinarily supple and may be braided like cord.

The irrigated land proper comprises the richest parts of the plain of Roussillon. Garden truck and fruits are the foundation of its prosperity. Irrigation is an ancient art here, and the Catalans are masters of the technique of irrigation: *rech*, *agulla*, *embegue* are the three Catalan terms to designate rank in the system. Garden stuff has long been raised on the good lands, copiously manured and tilled with loving care, but formerly the products were destined for local consumption only. In 1750 there were 100 hectares of gardens around Perpignan; about 1850, 900 hectares. Since the beginning of the twentieth century progress has been rapid, and now the plain boasts 3700 hectares and almost continuous production. Sometimes four harvests a year are gleaned from the same patch of ground. Six trains a day in winter and nine in summer transport the garden stuff to market.

The present crisis has, of course, been felt here as elsewhere, but the real advantages of a warm winter, a high mean temperature, and abundant water will always assure Roussillon a privileged place in the western European market. The tonnage transported by rail in 1931 consisted chiefly of salads (27,100 tons), tomatoes (1300 tons), and peaches (12,700 tons).

Irrigation is not used for garden truck only; great extents formerly devoted to wheat are now irrigated vineyards. Their grapes, however, produce only an inferior wine, though they give yields up to 200 barrels a hectare. Under present conditions overproduction is certainly a mistake.

All this irrigated part of Roussillon forms a mass of deep verdure, from which emerge the great plane trees, the beautiful poplars, the hedgerows of cypress to break the terrible north wind, the tramontane wind, and the exotic silhouettes of palms, acacias, and eucalypts.

The *aspre* or nonirrigated part has a very different aspect. Man cannot combat the great dryness of summer (an average rainfall of 3.5 inches for 3 months at Perpignan) or the violent wind that increases the evaporation. He must resort to dry farming. Up to the middle of the nineteenth century the good soils were planted to cereal crops, a fallow year alternating with a crop year. The fallow year was associated with the transhumance to be spoken of later. On the rockier places the olive, almond, and vine were the accepted cultures in spite of the dryness. But since the middle of the nineteenth century vine cultivation has triumphed over everything else. The plant has deep roots and can penetrate to the necessary water. Unlike that of the wine from the vines of the irrigated lands, the quality here is good and on the slopes is even superior. The wines of Banyuls in particular, which has a small yield of 20 to 30 hectoliters to a hectare, are among the best sweet wines.

This viticultural development has caused the neglect of all other crops except hay for fodder for the horses used in the vineyards. The olive and almond cultures are in complete decline. The cork oak that forms fine forests at the foot of the Albères and the Aspres du Canigou languishes in spite of the excellence of its product. In some places, however, orchard trees are cultivated for their early fruits, cherries in particular, which ripen before they are attacked by insect pests.

The picture of Roussillon shows a natural landscape completely overturned. Old Canigou may well look down with astonishment on the autumnal sea of multicolored vines in place of the somber tints of a vast forest of evergreen oak. Man has changed all, but here he has done it reasonably, for it is reasonable to cultivate lands adaptable to cultivation. It is otherwise with the mountain to which we now turn.

Fenouillèdes and the Corbières

The regions united under this name have little homogeneity and are best divided into three parts. The first includes the limestone massifs of the Corbières with holm oaks and aromatic *garigue*.

Although he has not attempted much in the way of cultivation, man has left a definite imprint on these areas. The limestone of the Corbières is essentially karst country, *lapies*, whose character suggests the former existence of a forest; but if such is the case it must have been removed in very ancient times, for Strabo, speaking of the part near the coast, contrasts the denuded north slopes of the Pyrenees with the more wooded south slopes. Some poor fragments of forest,

5 (upper)—Notre-Dame-de-Laval, near Caudiès in
llèdes. Here the traveler from the west sees the first
signaling the approach of Mediterranean conditions. In
tance the great tectonic valley of Fenouillèdes between
rbières (left) and the Agly (right).

6 (middle)—Vineyards and orchards of Roussillon. In
ckground the Albères; in front the compact village
neration (right); the shelter belt for the fruit trees; and
nd fruit trees in the foreground.

7 (lower)—La Manère in Upper Vallespir. In the middle
to the left, the village with terraces for vegetable gar-
behind chestnut plantations; in background the mountain,
ntier with Spain, beech-clad on its northern flank.

FIG. 8 (upper)—The Cerdagne at Eyne. In the foreground hay fields, irrigated and bordered by pollarded willows and poplars; beyond the village, meadows, the pine forest of Font Romeau, and finally the slopes of Carlit towards the Puig Péric.

FIG. 9 (middle)—Terraced vineyards of Banyuls. Trenches collect and carry off the storm waters. The stream, almost dry in summer, is bordered in part with nettle trees. The upper slopes of the mountains are in garigue.

FIG. 10 (lower)—The cirque of Font Nègre, partly in French, partly in Andorran territory. The black patches at the base of the cirque are rhododendrons; above talus slopes and bare rock. The highest summit, center, is 2852 meters.

however, remained up to the middle of the nineteenth century, preserved for the use of the bark in tanning. The day when other sources of tanning materials were discovered the woods were burned over, and now only goats and their herders are to be found in these solitudes. Some parts have the appearance of most desolate stony deserts. In the parts farthest from the sea, higher and wetter, splendid fir forests

FIG. 11—Notre-Dame-du-Coral, Upper Vallespir, between Prats de Molle and La Manère. A place of pilgrimage with accommodations for the pilgrims and also an important farm. Note the outside stairs, the walled court, and the slight pitch of the roofs to the gutter, characteristic of Mediterranean countries.

colonize the *lapies*, showing the "forestal vocation" of this type of terrain, whose deep fissures conserve moisture. In the depressions where clay has accumulated in the process of decalcification, cultivation is possible, especially of the vine; but such areas are minute in size.

The action of man, installed for some millenniums on these lands, whose burning aridity wounds the sight of the traveler, has been disastrous. By rights these are forest lands, and they should so remain.

The second division is that of the siliceous massif of Agly. The lower slopes and valley bottoms are well enough developed. They can be irrigated in part. Each proprietor formerly had a little watered land for his garden, a few vines for his wine (incidentally a wine of superior quality), a field for his bread, a bit of hillside for his olives and oil. The system, the result of an occupation of the soil during many millenniums and of the passion of the French peasant for his bit of ground, has resulted in an extraordinary comminution of property. One owner at Maury has 186 different pieces of land! Out of 482 proprietors 376 own less than 5 hectares each.

In the higher parts the old woods have disappeared. There was

need of winter and spring pasturage for the livestock that summered on the mountain. But in these Mediterranean countries grass is scarce; conditions are more favorable for shrubby growth. The cistus (rockrose) *garigue* that has invaded everywhere affords only a painfully won nourishment to the flocks. In the Fenouillèdes region it takes 2 hectares of *garigue* to support one sheep!

At the time of maximum density of population stubborn toil wrested a harvest from these mountain lands: now they are abandoned for the most part, and there is left an unbeautiful country with the disinherited and melancholy air of things that are no more.

FIG. 12—Prats-de-Molle. Upper Vallespir. Vauban's fortifications have been in part removed. Narrow streets make for coolness in summer. The square clock tower is characteristic of Catalan architecture. The market place has a large plane tree, a common sight in Roussillon.

Forests still exist toward the summits of the Fenouillèdes that have a share in the Atlantic climate, beech and fir on the wetter parts, Scotch fir on the drier. But the handiwork of man is evident enough in the felling of the useful firs and the clearing of the forest to the profit of the wastelands. Parts of the forest are protected by the Forestry Administration, and here under good management are found the finest firs of the eastern Pyrenees. An example of a fine beech wood is seen in Figure 13.

THE CONFLENT

The Conflent[2] is the valley of the Têt confined more or less sharply between the massifs of Madres and Agly to the north and the high chain of Canigou to the south. It is a region of varied topography. High peneplain surfaces above the abrupt slopes facilitate communication with the high plateaus of Cerdagne and Capcir and make of the Conflent a region both of passage and of refuge.

[2] A part of the Conflent was described by Roderick Peattie in "The Conflent: A Study in Mountain Geography," *Geogr. Rev.*, Vol. 20, 1930, pp. 245–257 (see also the critique by P. Arbos in *Rev. Géogr. des Pyrénées et du Sud-Ouest*, Vol. 1, 1930, pp. 505–508).

Man has found here the necessary resources for a self-contained economy. The lower valley permits all the rich cultivations of Roussillon and is in fact better sheltered from the wind than the great plain. The patiently walled slopes are adaptable to terrace cultivation. Abundant water keeps the meadows green. The steep and rocky slopes are forest-clad, and on the heights are the summer pastures, where some temporary cultivation can be practiced, thanks to the prodigious growth of the vegetation at these altitudes. Abundant mineral riches bring a supplementary resource. In short, all is disposed for a broad human use. Unfortunately equilibrium in the mountain is delicately balanced, and the forest is a fundamental element in that balance. The Conflent is deficient in this respect.

On the flat bottom the easily irrigated plain has gone through the same evolution as the plain of Roussillon. Formerly wheat was the staple crop; now early vegetables, other vegetables, and fruits are the most remunerative. On the slopes the irrigation channel has transformed the country as at the wave of a magician's wand. Above is the *aspre*, gray and rocky; below, the deep green of meadows and arable. Where the ground is flat enough, cereals are grown; but the special product of the Conflent is the apple. The apples, Canadian reinettes, with those of Vallespir, are the best in the whole Midi, and I do not know of any more delicately flavored apple anywhere else in the world. Irrigation, however, has certain attendant disadvantages. Where loose soils rest on steep slopes, infiltrating water is likely to cause dangerous landslides.

The nonirrigated part, the *aspre*, above the canal, has been cleared from the forest for the building of terraces. Centuries of toil are represented by these dry-stone walls that build up shelves and minute flat patches for a few olives or vines. Labor does not end with the erection of the walls; the soil that the storms sweep away must constantly be carried back, and all work must be done by human muscles as the sole motive power. The Mediterranean is girdled with a band of such terraces, eloquent alike of human will and human need.

Man, unfortunately, has attacked the forest excessively. The mines have been one of the chief reasons for its destruction and for the abandonment of the more difficultly cultivable land. A disastrous train of consequences has followed. The unchecked torrents sweep down material from the abundant glacial deposits at the foot of Canigou. Corrective works are necessary to protect the lower valley against catastrophic inundations. Some attempt at reclamation has been made by planting chestnut trees in the bottom of the ravines in places of more humid soil. Forest should be restored as soon as possible to protect the slopes. The question of the high-level temporary cultivations is closely related to pastoralism and will be taken up in connection with the high plateaus of Cerdagne and Capcir.

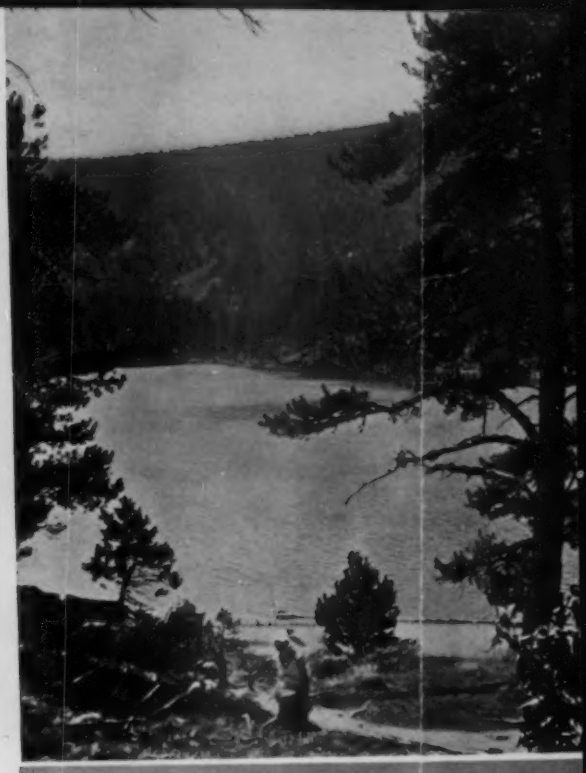


FIG. 13 (upper)—The forest of Boucheville, Fenouillèdes.
FIG. 14 (lower)—Looking from Usson to the snow-covered massif of Madres. The gorge of the Aude in the center, ruined castle on spur to right, and beyond the cultivated fields of the plateau of Donezan. In the background Madres.

FIG. 15 (upper)—Étang de Balcera, glacial lake in Capcir.
FIG. 16 (lower)—Observation tower in the Albères. Mediterranean and mountain vegetation zones come in direct contact, the deciduous oak zone having practically disappeared as a result of fire and grazing by goats.

Vallespir and the Albères

The most distinctive phase of human activity in the southern mountains is the chestnut cultivation. It is related to the neighboring viticulture of Roussillon: chestnut wood is largely employed in the manufacture of casks, vats, and stakes. The development is not peculiar to Vallespir. Around the periphery of the great Mediterranean vineyard belt of France a chestnut belt is to be found—the Black Mountain, Cevennes, Maures, and Esterel. Chestnuts bring in much more than other crops, even the vine, that could be cultivated in their place.

The fields in this country of narrow valleys are small. Potatoes and rye, mountain crops, occupy the upper parts of the high valleys; the meadows, the delicious apple, and other orchard trees, the lower parts.

The lower slopes of these siliceous mountains are under the Mediterranean regime. Here are well-cared-for forests of cork oak, strange in the appearance of the red trunks after the periodic stripping. To permit freedom of movement and to prevent fires, a war is waged against the underbrush of tree heath and rockrose ever ready to form an impenetrable maqui. Outside the cork forests the mountain is now covered with a spiny maqui, periodically ravaged by fire. It takes the unique voracity of a goat to forage in such vegetation.

The higher parts of the mountains are at the beech-fir level, and many signs and historical documents show that forest formerly covered vast areas in upper Vallespir. The nearness of the sea permitted easy disposal of the products; the existence of mines and ironworks encouraged the consumption of much wood; the wish to increase the area of pastures and crops joined in causing an intense deforestation. But the depopulation of the scattered villages in turn led to the abandonment of such marginal sources of livelihood. The broom-covered wastelands have been colonized by bracken, and wind-borne seeds of trees are ready to reconstitute the forest if they have any assistance. Nature is ready to repair the faults of man if erosion has not cut the land to the quick; in that event man must undertake costly works of reclamation.

The High Plateaus and Mountains

The high altitude of the undulating surfaces of Capcir, Cerdagne, and the Upper Conflent present man with very different conditions from those that we have just examined. The insecurity of the valleys and plains fixed population in the highlands long years ago.

The summer is a magnificent season: strong insolation with powerful actinic effect permits the harvests to ripen in a short time even at altitudes of 1600 or 1700 meters. Vast stretches of succulent herbage

have for centuries supported a pastoral industry. The great forest of resinous species (Scotch fir in the sun, fir in the shade, mountain pine in the higher parts) proved an obstacle to the intensive activity of summer, and deforestation has been too common. The pastoral farmer, accompanying his cattle to the high grasslands, attempts to raise a crop on the best ground manured by the beasts. The temporary cultivation thus set up often involves migration of the members of the entire family and farmyard.

But the reverse of the picture is a rigorous winter, sunny but cold. Snow covers the ground up to the month of May at an altitude of about 1600 meters. There is a serious problem in feeding the herds during the long winter months. It has been solved by clearance of the forest, by transhumance, and by growing crops of hay. When exchanges were established with the plain, it was learned that the plain could not support many cattle during the burning summer and that the mountain had too many for the snowy winter. On the other hand, the herds could summer on the mountain and winter on the plain with nourishment the year round. Thus that form of pastoral economy known as transhumance was initiated,[3] with its professional herdsmen, its designated routes, its whole paraphernalia ruled by customs as strict as those governing irrigation.

In addition to grazing transhumants on their pastures, Cerdagne and Capcir have their own cattle also. But these are insufficiently nourished in the winter. As soon as the snow melts, the famished beasts voraciously devour the first new shoots, and the pastures in consequence have been progressively impoverished. The rare herbage of the forest is also sought out, to its ruin and the prevention of its regeneration. A great work of improvement is needed here.

As regards agriculture in these high basins, the tendency is toward specialization in hay and potatoes. In the lower parts of Cerdagne pear growing has been extensively developed since the railway has opened up a market for the product.

The Future

In the preceding pages a picture has been given of the chief historical changes in the agriculture of our region—its evolution from small-scale self-contained economy, through self-contained economy on a larger scale (the present *département*), based on the interdepend-

[3] This transhumance concerns interchange over a great distance; for example, between Cerdagne and the plain of Roussillon. Little transhumance, between the plain and the mountain directly overlooking it, is of much greater antiquity. See Sorre, Les Pyrénées méditerranéennes.

It is presupposed that here agriculture preceded transhumance (but not cattle raising). It is often considered that in the Mediterranean countries transhumance preceded agriculture. However, it seems necessary to distinguish the settlement of Cerdagne from that of the plain. The forested valleys with their abrupt slopes must have been a grave obstacle in the beginning. Transhumance in Cerdagne was first directed toward Spain. There are many doubtful matters in these questions of historic economies.

ence of the several parts, to modern conditions with specialization based on the development of means of communication, in which the limits are, at a minimum, the whole of France.

It must be remarked that the peasant whose horizon is limited to the immediate surroundings of his own village has worked out an equilibrium on his land, but if urged forward by the desire of gain he is tempted to exceed the limits of its possibilities, with serious consequences. The present reduction in population and a clearer view of wider interdependences will without doubt permit the establishment of a more permanent equilibrium in closer conformity with nature.

Prophecy is dangerous; but one may be permitted to envision some reasonable improvements. In the same way as the geological past has left its mark on the vegetation, the past systems of agricultural economy have left unfortunate traces, which must be effaced. Man has been imprudent in the extremes to which he has carried deforestation. If he did well on the whole in clearing Roussillon, he would have done better to leave more windbreaks; to keep in woodland the rocky sides of Argelès and Cerbère; to leave to the *côte vermeille* its adornment of pines and to enrich it with flowers and palms; to leave the slopes for the vine culture of Banyuls. But the great mistakes have been the denudation of Corbières and the devastation of the forests of Canigou.

Forested slopes are in the order of nature, an order it is dangerous to disturb. Man has sterilized the Corbières; he has delivered the flanks of Canigou to the ferocity of the torrential rains and floods. The rivers, which should be the source of fertility, cover the soil with infertile stone. Here intelligent man must repair the fault of ignorant man. Stream regulation and afforestation must restore the ancient order.

Surveying this beautiful country of the eastern Pyrenees from the summit of Canigou one sees how man can utilize its natural resources while having due regard for the rights of nature: high pastures covered with a succulent herbage nourishing flocks and herds in the summer season; on the steep slopes a broad girdle of deep forest crisscrossed by roads and trails for tourist and forester and showing harmonious combination of trees useful for the mountain and for man; the smiling plain watered by limpid streams contemplating in its richness the *muntanya coronada de plata i vestida de flors* that makes its inexhaustible prosperity.

THE AUSTRALIAN SAND-RIDGE DESERTS

C. T. Madigan
The University of Adelaide

ALTHOUGH it cannot be said that there are any areas remaining unexplored in Australia, yet there are vast inland regions, the so-called deserts, that have been crossed by only a few explorers and prospectors, whose trails may be a hundred miles apart. So inhospitable and remote are these regions that something in the nature of an organized expedition is still necessary before any attempt can be made to penetrate them. The greatest stories of Australian exploration are all connected with the efforts to conquer these deserts; but the journals of the explorers give little information about them. Sand hills and sand ridges are cursed for their menacing obstruction and endlessness, but very few definite facts are recorded about their trends or other characteristics.

The conquest of the air has ended the old heroic days of land exploration. Deserts across which the early explorers blazed their single trails in months of toil and tribulation may now be explored and roughly mapped in comfort from the air during a few hours. In terms of country visible, the track of the airplane is more than fifty miles wide, whereas in flat country the man on the camel can see no more than half a mile on each side of his path.

In 1929 it fell to my lot to pioneer the use of the airplane in Australia for geological and topographical work[1] when the Royal Australian Air Force lent me two machines to explore the dry lakes of the far north of South Australia and the then unknown and uncrossed desert north of Lake Eyre, which I named the Simpson Desert.

Since then Mr. Donald Mackay has done considerable aerial mapping in southwestern Central Australia during private expeditions, and at present there is a burst of aerial activity by gold-mining companies, particularly in Western Australia, in addition to the aerial geological work undertaken by the Commonwealth in recent years. Thus our knowledge of the trackless areas is rapidly increasing.

The aerial observer has an immense advantage over the man on the ground in the recognition of trend lines of any kind, be they due to vegetation, drainage, rock structure, or soil differences. That such trend lines are especially marked in the case of sand hills or sand ridges was brought home to me on my first flight in Central Australia. The traveler by train through the Depot Sandhills, the western extremity of the Simpson Desert, would certainly not be impressed with any definite trend of the sand hills, though he might notice that some

[1] C. T. Madigan: An Aerial Reconnaissance into the South-Eastern Portion of Central Australia, *Proc. Royal Geogr. Soc. of Australasia: South Australian Branch, Sess. 1928–1929*, Vol. 30, 1930, pp. 83–108.

appear to run parallel to the railway; yet from the air they were seen to be very long, straggly, and continuous parallel ridges running north-northwest. Their extraordinary regularity was a matter for thought. Ground observations showed that the direction of sand movement was along the length and not transverse to it, and I soon realized that these were longitudinal ridges, parallel to the prevailing winds. I then decided to consult all the available literature and to attempt to delineate the sand-ridge areas and to correlate the trend lines with the directions of the prevailing winds. I subsequently discovered that the same thing had already been done by M. Aufrère[2] for the sandy areas of the western Sahara, his work also being based on aerial photography, carried out by the Service Géographique de l'Armée.

Griffith Taylor, writing on the arid lands of Australia, refers to two areas of sand ridges, one extending from Ooldea on the Trans-Australian Railway for a thousand miles to the northwest to the coast at Wollal, and the other between Lake Eyre and the Barkly Tableland. He remarks that the sand ridges tend to run parallel to the dominant winds and shows the areas on a rough sketch map.[3]

The sand-ridge deserts are shown on Figures 1 and 2. The eastern area and the Great Sandy Desert are entirely occupied by parallel ridges. In the Great Victoria Desert the ridges are more scattered and have wider stony areas, their arrangement is less regular, and their boundaries are therefore less definite. The boundaries were drawn conservatively. South of the MacDonnell and James ranges, for instance, in the area between Ayers Rock and the overland telegraph line, there is a great deal of sand; but this is partly occupied country, and the sand is not in well marked ridges. The east-west transcontinental railroad is not entirely free from sand, but except at Ooldea it is not a conspicuous feature. The eastern area occupies about 115,000 square miles. The Great Victoria Desert as delineated occupies 135,000 square miles south of the 26th parallel, and the other western deserts, the Gibson and the Great Sandy, together occupy 235,000 square miles.

The Dominant Winds

Taking Australia as a whole, there are two prevailing winds, the westerlies of the south coasts and seas and the southeast trades. These two dominant influences are highly modified by the monsoon effect of the continental island. In the summer the accentuated monsoonal

[2] L. Aufrère: L'orientation des dunes continentales, *Rept. of Proc., [12th] Internatl. Geogr. Congr., Cambridge, 1928*, Cambridge, 1930, pp. 220–231; *idem:* Le cycle morphologique des dunes, *Ann. de Géogr.*, Vol. 40, 1931, pp. 362–385.

[3] Griffith Taylor: Geography and Australian National Problems, *Rept. 16th Meeting Australasian Assn. for the Advancement of Sci., Wellington Meeting, 1923*, Wellington, 1924, pp. 433–487, reference on p. 468; *idem:* Uninhabited Australia; and the Reasons Therefor, *Proc. [2nd] Pan-Pacific Sci. Congr., Australia, 1923*, Melbourne, 1924, Vol. 1, pp. 659–664, reference on p. 662; *idem:* Agricultural Regions of Australia, Instalment I, *Econ. Geogr.*, Vol. 6, 1930, pp. 109–134, map on p. 114 (Fig. 5).

low-pressure area tends to keep centered toward the northwest margin of the continent, and the highs are in the southeast. In the winter the highs advance inland but are still in the main centered in the southeast, and the low-pressure area moves northward, though part of the north coast is still within it. Thus the general tendency of circula-

FIG. 1—Map of Australia showing areas of sand-ridge desert. The nearest "towns" bordering the deserts are shown. There are no settlements of any kind inside the western areas; some of the important springs are indicated. In the eastern area the towns of Innamincka and Birdsville are shown; there are also scattered and mostly unoccupied stations in the Cooper and Diamantina country. All the railways that stretch towards the interior are also shown: they represent the limits of optimism of the various State governments and of the Commonwealth in the case of the Northern Territory. Scale 1 : 43,000,000.

tion remains the same throughout the year, owing to a persistent pressure gradient across the continent from southeast to northwest. The southeast trades blow continuously in the central and northeastern areas, but in the western interior the wind swings left, obeying Ferrel's law, and becomes an east wind. The wind roses on Figure 2 show this clearly. The eastern stations indicate the dominant southeast trades, the western stations the prevailing easterlies. At the eastern stations there is a steady increase in the southeast trades northwestward from Farina and Thargomindah through Charlotte Waters and Boulia to Alice Springs and Tennant Creek and a corresponding decrease in the importance of southerlies. At these stations the north and northeast winds blow in the spring and summer, the trades becoming more dominant in the autumn and winter, when the monsoonal lows have disappeared from the west. The wind roses show very well the swing to the left of the winter southerlies. The dominant southerly

of Farina changes to a dominant southeasterly at Alice Springs and Tennant Creek and an easterly at Halls Creek and thus traverses the continent in a great westward-trending arc. One of the chief objects of this paper is to bring forward the point that the trend of the sand ridges follows this arc exactly.

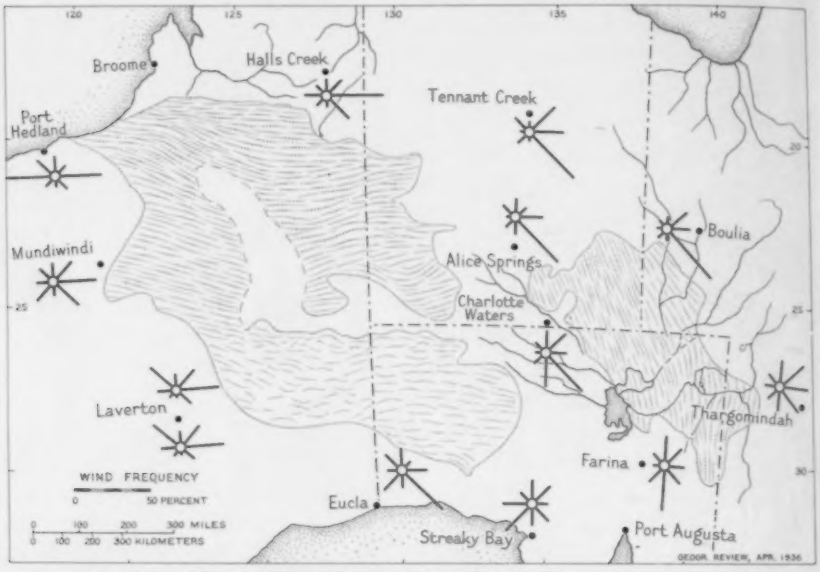


FIG. 2—Map of Australian sand-ridge deserts showing trends of sand ridges and the annual wind roses for the meteorological stations nearest the sand-ridge areas.

The wind roses were compiled from figures (given by Mr. W. S. Watt, Commonwealth Meteorologist) for the percentage frequencies for each station for the eight points of the compass at 9 a. m. and 3 p. m. for each of the four seasons. These were reduced to a mean frequency percentage for the whole year so that the lengths of the lines radiating out from each station show approximately the percentage of the total winds that blew from each direction. No data were available for the wind velocity. Winds in the interior of Australia, however, rarely exceed 20 miles an hour. Scale 1 : 25,000,000.

The three maps of Figure 3 show the mean isobars for the year, for summer (January), and for winter (July). To the map of annual isobars have been added the prevailing wind directions: the southeast trades of northeastern Australia, the east winds of the northwest coast and the southern central area, the east-southeast winds of the western center, and the east-northeast winds of the center of the continent. There are no records from this center, but the isobars and the known trend of the sand ridges both indicate a northerly component of the east winds. The great arc of sand-ridge trends across the center of the continent is also indicated. The trend of the ridges is exactly parallel to the known prevailing winds, and the maps show that the direction of the prevailing winds may be determined in areas lacking meteorological records by reference to the sand ridges.

On the map of summer isobars the known prevailing winds of summer are indicated. They differ from the annual winds in the frequency

of northeast winds in the northeastern part of the continent and in the reversal of direction along the north and northwest coasts. These reversed winds, owing to their relative frequency, must be regarded as secondary. The map of winter isobars shows directions much more similar to those of the annual winds. The chief difference is in the change from east to northwest winds in the southwestern areas.

The wind roses show the dominant winds over the western sand-ridge area to be easterly. The winds of Streaky Bay have no influence on the sand ridges. Eucla also is rather far from the sand-ridge deserts. Southeast winds predominate, being strongest in the spring and summer. Some strong east winds blow in the summer and some strong west winds in the winter. At Laverton east winds predominate in all seasons except winter, when the northwest winds are conspicuous. The northeasterlies are distributed throughout the year. East winds also predominate at Mundiwindi, and the seasonal and annual wind roses are similar. At Port Hedland east and southeast winds blow

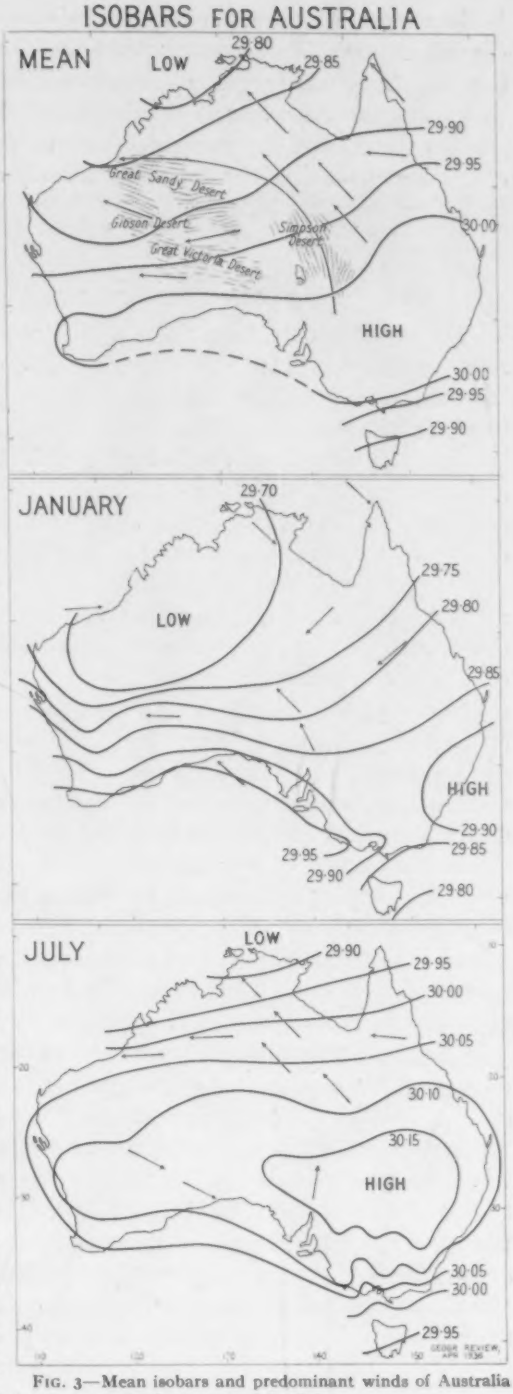


FIG. 3—Mean isobars and predominant winds of Australia for the year, for January, and for July.

in the winter, west and northwest winds in the summer. Nearly all the east winds are morning land breezes and the west winds afternoon sea breezes. This is the region of occasional violent hurricanes in the summer when the lows are centered around that coast. Finally, Hall's Creek again shows the prevailing east wind, to which the sand ridges of the desert south of that place conform in direction. The west winds there are summer winds.

Sand-Ridge Trends in the Eastern Desert Area

The eastern desert area lies on the southwest side of the Great Artesian Basin, and abundant underground water is available at depths of as much as five thousand feet. There are many bores, but the area is the most arid in Australia, its rainfall being only five inches or less. The elevation nowhere rises above 500 feet above sea level and falls some forty feet below it in Lake Eyre itself. The surface consists of stony or "gibber" plains, sand ridges, and, in the delta country only, of scattered mesa-like remnants of an older peneplain.

Cooper Creek and the Diamantina River, with their tributaries, make a great alluvial delta of the southeast end of the desert. Both rivers meander through the country for some two hundred miles, in countless channels and through hundreds of lakes and swamps. In many places there is no main channel. The map suggests a fertile country of lakes and meadows, and so it was thought to be in the days of Burke and Wills, more than seventy years ago. It is a land of promises that have never been fulfilled and never will be in the present geological cycle. In Pleistocene time giant marsupials wandered over the grassy plains of this region, but now their bones lie bleaching where they perished round the margins of the great salt pans that once were lakes. Lake Eyre's 4000 square miles are covered with a foot or two of salt and are destitute of water except for small patches for a few weeks after the rivers have run. The Diamantina, which floods annually past Birdsville, reaches Lake Eyre only once in every few years (the last time was in 1930), and the Cooper reaches the lake perhaps on an average of once in a decade (it has not done so since 1918, however). The floodwaters fill the upper lakes and spread for miles over the flat plains but evaporate soon and leave only a few permanent water holes. There is rarely any water to be obtained along the 300-mile cattle track from Birdsville to Marree, except at the bores. The whole area is a barren steppe except during one of the rare good seasons. The cattle stations opened so hopefully fifty years and more ago are almost all abandoned now, and the country is practically uninhabited. The only cattle today are near Birdsville on the Diamantina and at Innamincka on the Cooper.

The whole district is traversed by sand ridges, in some places a few

chains apart, in others several miles. They are straight and parallel and in places run for fifty miles without a break. The areas between the sand ridges are stony or clay flats. Those near the watercourses are subject to inundation at times, and the narrow lakes and swamps on the survey maps show the trend of the ridges. Cane grass (a coarse

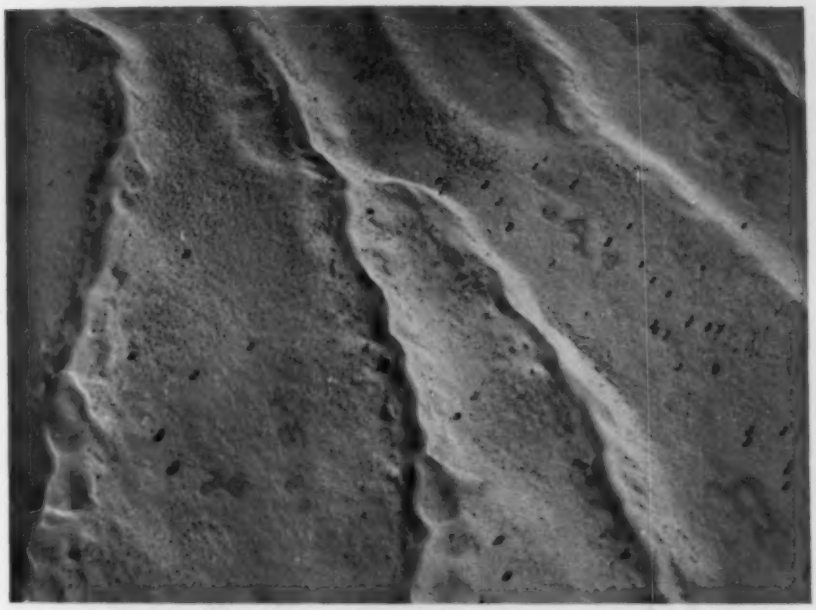


FIG. 4—Sand ridges east of Lake Eyre on the Birdsville track; trend north-northwest; view about one half mile across. Needlebush and spinifex. Note the superimposed crescentic dunes due to northeast winds. Photograph from 4200 feet.

variety of spinifex), needlebush (a *Hakea*), and hopbush grow on the ridges, and on the flats between are patches of cottonbush and saltbush, with grasses in good seasons.

South of the Cooper the sand ridges are more irregular, smaller, and more numerous, and the country is barren and unoccupied all the way to the Flinders Ranges. Between the Cooper and the Diamantina the sand ridges are larger and farther apart, and the stony areas are larger. North of the Diamantina the great sand-ridge grid of the Simpson Desert begins and runs for 400 miles to the northwest. At first the sand ridges are wavy and more scattered, but they soon become a grid of parallel ridges hundreds of miles long and perfectly straight—surely one of the most remarkable physiographic regions of the world.

Sturt,[4] who was the first to enter this region (1845), was one of the few explorers to record the trends of the sand ridges. He noted the trend east of the Strzelecki as N 6° E and north of the Cooper as N 2°

[4] Charles Sturt: Narrative of an Expedition into Central Australia . . . during the Years 1844, 5, and 6, 2 vols., London, 1849.

W. The portion of the desert in South Australia has been triangulated by the South Australian Surveyor General's Department, with the exception of that part of the Simpson Desert north of Lake Eyre and west of the 138th meridian. Many of the pastoral leases were mapped in great detail, every sand ridge being recorded. These surveys show the trends to be as much as N 15° E in the country south of Innamincka and east of the Strzelecki; west of the Strzelecki the trend is N 10° W, the sand ridges are half a mile apart, and some of them are 40 miles long.

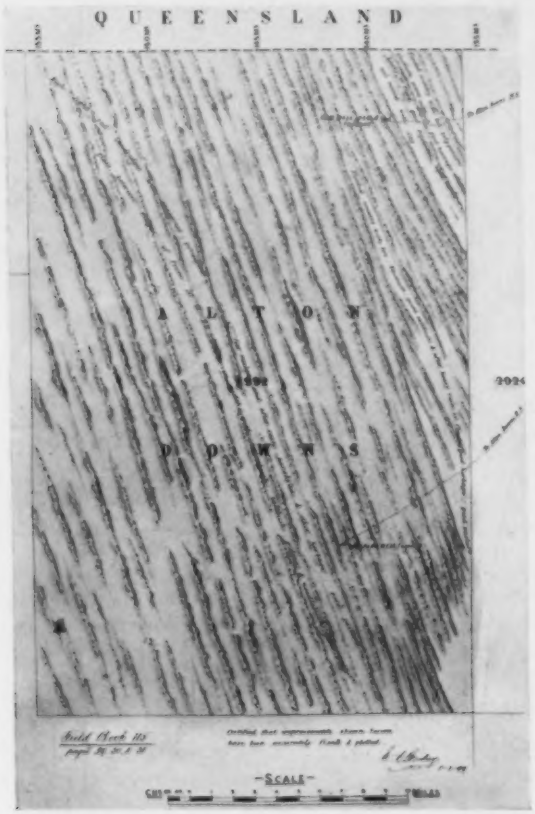


FIG. 5—Surveyor's map of Alton Downs Station, north of the country seen in Figure 6. Note straightening of the sand ridges.

Figure 5, showing the survey of the Alton Downs station, gives an excellent idea of the sand-ridge deserts in general. The block shown measures 30 miles by 20 miles. It is crossed by some forty-three parallel sand ridges trending N 20° W. They average about three-quarters of a mile apart, and two of them are 25 miles long.

I have examined these sand ridges on the ground only at Birdsville. There they are not more than 50 feet high above the intervening gibber flats; their average height is perhaps 30 or 40 feet. Throughout all the deserts the sand ridges are fixed with vegetation, mainly spinifex (*Triodia irritans*), with its hemispherical masses of spiky leaves. At Birdsville the coarser cane grass is common in large bushes. The summits of the ridges, however, are invariably occupied by loose drift sand, which forms in small superimposed crescentic dunes transverse to the direction of the wind that happens to be blowing—a northeast wind at Birdsville in the summer. One anomaly noted is that at Birdsville the northeast side of the ridges is the steeper, whereas the wind rose for Boulia would seem to indicate that the southwest side

might have been expected to be the steeper, inasmuch as the most prominent secondary wind is from the northeast. The west winds, however, show the highest percentage of velocities of more than 20 miles an hour.

At Birdsville definite evidence was obtained that the sand is moving in the direction of the trend of the ridges. The ridges were noted to be encroaching on the southeast side of the flooded land of the Diamantina; the northwest ends of the ridges were advancing and covering trees. On the South Australian side of the border this movement was well recognized by the pastoralists, one of whom told me that if I could only wait long enough all his sand would go into Queensland.

Another clear proof of the longitudinal advance was seen in the contrast between the ends of the ridges. At the northwest end there was invariably a tongue of fresh sand extending out over the gibbers; at the southeast end retreat was shown by residual columns of sand capped by cane grass and bound together by its roots (Figs. 9 and 10).

The Simpson Desert

This area of 43,500 square miles lies between the Finke River on the west and the Queensland border on the east and extends from the Marshall River in latitude 23° S. southward to Lake Eyre in latitude 28° S. It is an ocean of spinifex-covered sand waves. The ridges are straight and parallel, a quarter of a mile to a mile apart, most of them probably not more than 60 feet high, though some rise to perhaps 100 feet. From the air they are seen to run from horizon to horizon, each ridge unbroken for the full range of vision, which may be 50 miles. Few of them converge; in places two meet and continue as one, and in that case the single ridge is invariably to the northwest of the junction.

Mr. L. A. Wells, the well known surveyor and explorer, now retired, was a member of Poeppel's party that chained the Northern Territory–Queensland border, and he has given me much interesting and valuable information. The sand ridges extend from Poeppel's Corner (i.e. the southwest corner of Queensland on the 138th meridian) for 180 miles northward. They average 30 to 50 feet in height. At the Corner they trend N 20° W, and this trend gradually becomes more westerly as one goes north, being N 25° W at 50 miles, N 30° W at 150 miles, and N 40° W at 180 miles, where the ridges end. The swing to the left of the prevailing winds as they blow northward is thus shown. Along the border the sand ridges average from four to six to the mile measured at right angles to their trend. Every ridge is recorded on the survey. It is interesting to note that the Northern Territory–South Australian border between Poeppel's Corner and Charlotte Waters has never been run. The Simpson Desert has never been crossed except well to the south of that line.

FIG. 6—The southeastern margin of the Simpson Desert. Sand ridges beginning at Goyder's Lagoon in the background. View looking southeast. The ridges run unbroken for 300 miles to the range shown in Figure 14, the northwestern margin of the desert.

East of the Queensland border the sand ridges become farther apart. On the gibber or clay flats between grow *Hakea*, desert oak, and grasses after rains. West of the border the flats show mulga and *Hakea* at first, but these give way to sand and spinifex between the sand ridges toward the center of the desert.

Northeast of Charlotte Waters a stony area projects into the sand ridges, but west of this area the sand-ridge desert opens out again and continues on to the Finke. This western extension is known as the Depot Sandhills, and the Alice Springs railway line crosses its west border. The rainfall here approaches ten inches. The vegetation is better—desert oak and the succulent parakilya, which makes a wonderful display of purple blossoms after rains. The trend of the sand ridges on the west side of this desert has swung more toward the meridian. It is parallel to the railway and runs about N 17° W.

The trends given by some of the early explorers must be taken with some reservations. Barclay,[5] for instance, gives the trend at Anacoora Bore, near Charlotte Waters, as N 15° 30′ W; Lindsay[6] gives it as N 45° W. Lindsay gives N 50° W for Crown Point on the Finke, which must be an error; Barclay gives north by west. Barclay's trends may be taken as correct. There is also a tendency to exaggerate the

[5] H. V. Barclay: Report on Exploration of a Portion of Central Australia by the Barclay-Macpherson Expedition 1904–1905, *Proc. Royal Geogr. Soc. of Australasia: South Australian Branch, Sess. 1914–1915*, Vol. 16, 1916, pp. 106–130.

[6] David Lindsay: An Expedition across Australia from South to North, between the Telegraph Line and the Queensland Boundary, in 1885–6, *Proc. Royal Geogr. Soc.*, Vol. 11 (N.S.), 1889, pp. 650–671.

heights of sand hills. Some explorers have mentioned 250 feet. No doubt it seemed that to them after they had been crossing the hills all day.

There are also sand ridges on the west side of the Finke, but these are less formidable; the country is better here and is held under pastoral leases. The ridges trend east of north, the Horn Expedition[7] of 1894 giving N 15° E at Mt. Watt.

Ralph Tate and J. A. Watt of the Horn Expedition[8] say of the sand hills encountered in the area between the South Australian border and Alice Springs and west to Ayers Rock that the ridges have a northeast-southwest trend, "due to the prevalence of S.E. winds . . . The trend of the sandhills is to a great degree dependent upon the direction of the prevailing wind, being almost at right angles to this." This theory is directly opposed to the one now put forward but was at one time generally accepted. The trends in the neighborhood of Ayers Rock are controlled not by southeast but by east-northeast winds (Fig. 2).

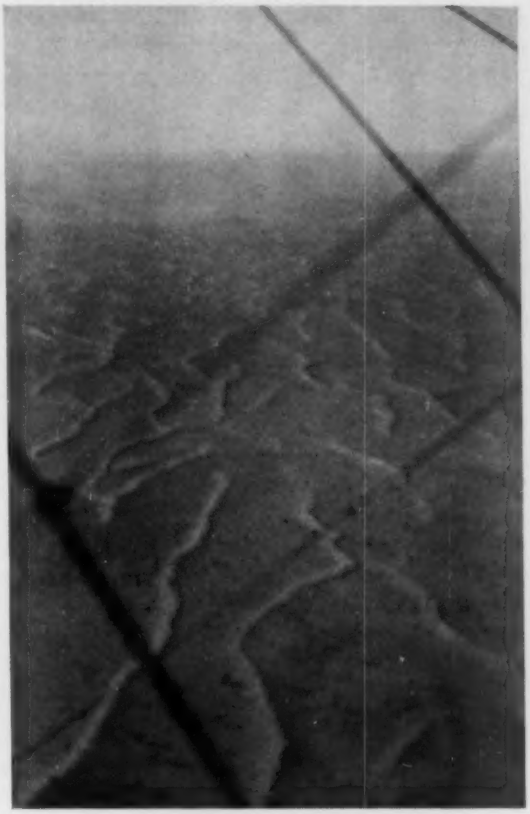


FIG. 7—Sand ridges of the Depot Sandhills, western side of the Simpson Desert, near Rumbalara on the railway line. Compare Figure 6. The wavy nature of the ridges is typical of the windward margins of the desert.

THE GREAT VICTORIA DESERT

The Great Victoria Desert is the southern portion of the western sand-ridge desert. Toward the east it is separated from the northern portion by the line of mountains that runs along the 26th parallel

[7] C. Winnecke: Journal of the Horn Scientific Exploring Expedition to Central Australia, 1894, *South Australia Parliamentary Paper No. 19*, 1896.

[8] Baldwin Spencer, edit.: Report on the Work of the Horn Scientific Expedition to Central Australia, 4 vols., London and Melbourne, 1896; reference in Vol. 3, p. 25.

from the Musgraves westward. It was along these mountains that Giles[9] made such heroic attempts to cross to Western Australia in 1872 and Forrest[10] triumphed in the opposite direction in 1874.

The country, flat, arid, and without permanent waters and any lines of drainage, is typical of the great peneplain of Western Australia. The rainfall is from 5 to 10 inches, increasing toward the north. The elevation is from 500 to 1000 feet above sea level. Sand ridges and sand hills are scattered throughout, but they are much farther apart, shorter, and more irregularly disposed than those of the Simpson and Great Sandy deserts. Explorers do not make much of the difficulty of crossing them, whereas travel by any means other than camels is impossible across the trend of the ridges in the other deserts. Motor trucks have crossed from Laverton to the Warburton Ranges without undue difficulty. Between the sand ridges and on the broad flats there is a sparse vegetation of acacias, *Hakea*, eucalypts, the universal spinifex, and, after rains, of grasses.

The most extensive journeys in this desert were made by Lindsay[11] and Maurice.[12] Lindsay only once gives a sand-ridge trend, namely a general trend of 290° in irregular sand ridges in latitude 29° 30′ S., longitude 124° 30′ E. L. A. Wells, who made a separate journey on the same expedition, gives a general trend of west-northwest for the sand ridges of the west margin of the Great Victoria Desert. He also notes that the ridges were steep on the south side. This would be due to the northwesterly winds of winter.

Maurice crossed this desert in a northwesterly direction from Ooldea to the Rawlinson Ranges. All his important topographical observations are to be found on the map accompanying his diary. He encountered sand hills all the way from Ooldea to the 26th parallel, where the ranges begin. He gives a trend of east by north in 28° 30′ S., 129° 30′ E., and writes of that locality that nothing could be seen to the south and southwest but sand hills, having a general east-west trend. He gives the trend as east-northeast in 27° 30′ S., 128° 30′ E. He returned through the Musgrave Ranges and along the 133rd meridian. Sand hills were not very conspicuous south to 27° 40′ S. Between 28° and 29° S. there were sandy undulations. He records east and west sand hills half a mile apart at 29°. R. L. Jack[13] gives on his map a trend of 280° in 27° 30′ S., 133° E., and refers to a general trend "between W. and N.W. to E. and S.E.," with steeper slopes on the

[9] Ernest Giles: E. Giles's Explorations, 1875–6, *South Australia Parliamentary Paper No. 18*, 1876; *idem:* Australia Twice Traversed, 2 vols., London, 1889.

[10] John Forrest: Explorations in Australia, London, 1875.

[11] David Lindsay: Journal of the Elder Scientific Exploring Expedition 1891–2, Adelaide, 1893, p. 104.

[12] R. T. Maurice: Explorations by R. T. Maurice: Fowler's Bay to Rawlinson Ranges, *South Australia Parliamentary Paper No. 43*, 1904.

[13] The Geology and Prospects of the Region to the South of the Musgrave Ranges . . . , *Geol. Survey of South Australia Bull. No. 5*, 1915, p. 25 and Pl. I.

FIG. 8

FIG. 9

FIG. 10

FIG. 8—The crest of a sand ridge at Pandi-Pandi Station, on the east side of the Diamantina, 10 miles south of Birdsville. View looking southeast.

FIG. 9—The southeastern end of a sand ridge near Birdsville showing erosion and removal of sand.

FIG. 10—The northwestern end of a sand ridge near Birdsville showing extension in a northwest direction over the gibber plains.

north side of the sand hills; he refers also to the "dominating influence of the S. to S.W. winds."

The latest reliable account of this desert is given by Talbot and Clarke,[14] who made a journey northeastward from Laverton to the Warburton Ranges, across the west end of the desert. They found the sand hills dense only between 125° and 126° E. and 27° and 28° S.

FIG. 11—Parallel sand ridges in the middle of the Simpson Desert. Dense spinifex and few acacias; ridges one quarter of a mile apart. Photograph from 2000 feet.

They record them as there being from 200 yards to nearly a mile apart and of an average height of 30 feet. They say the ridges ran in no particular direction but were parallel for considerable distances, though north of the 26th parallel the trends were very regular in an east-southeast to west-northwest direction. This they rightly ascribe to the comparative variability of the winds in the more southern areas. They also state that the uniform direction of the ridges farther north is doubtless due to their formation parallel to the direction of the wind.

Carnegie[15] wrote of the northwest corner of the Great Victoria Desert that "sand-ridges now E. and W., now S.E. and N.W., now S.W. and N.E. (as in the vicinity of Empress Spring), and now sand-hills heaped up without regularity, alternate with mulga thickets, open plains of spinifex, and flat, timbered country."

All these observations seem to show that in the Great Victoria Desert the ridges are shorter and more irregular than in the other deserts and that the trends have a mean easterly direction, with a

[14] H. W. B. Talbot and E. de C. Clarke: A Geological Reconnaissance of the Country between Laverton and the South Australian Border (near South Latitude 26°), *Western Australia Geol. Survey Bull. No. 75*, 1917.

[15] D. W. Carnegie: Spinifex and Sand, London, 1898, p. 178.

tendency to north of east in the central parts and to south of east in the western parts.

The Great Sandy Desert

This desert is similar to the Simpson Desert in the outstanding development of parallel sand ridges, evenly spaced and of unvarying

Fig. 12—Where the Hale River floods out in the Simpson Desert. Note the parallel lines of trees in the flats between the sand ridges and the course of the stream parallel to the ridges.

trend over large areas. The rainfall ranges from 10 inches in the south to 20 inches in the north, but there is nevertheless a complete lack of permanent surface water, and there are no drainage lines. The vegetation on the stony areas is much like that of the Great Victoria Desert, though probably rather more plentiful. Spinifex and mulga (*Acacia aneura*) are always the typical flora, though mulga decreases toward the north and mallee scrub (a eucalypt) and other bushes increase. I have not penetrated any part of this desert but have skirted its east side on a journey from Alice Springs to Tanami. On that side the vegetation is comparatively dense, so that the ground is hidden except at one's feet, and from a high point the country has exactly the appearance of a gray-green ocean. The effect is increased among the sand ridges, where the waves are also represented. This region is very different from the gibber country of the eastern desert or of the plains to the west of it on the artesian basin, where in many places no vegetation at all can be seen, and the observer is in the center of a yellow-brown disk extending to the horizon.

The Great Sandy Desert lies on part of the great peneplain of Western Australia. Its elevation is 1500 to 2000 feet. A stony area

of fewer sand hills extends into the sand-ridge desert northwestward from the Warburton and Petermann ranges. The margins of this area were defined in eight widely separated places from the accounts of the expeditions mentioned below.

Warburton,[16] who was the first to make an inland crossing from Central Australia to Western Australia, was also the first to encounter

FIG. 13—Barren sand-ridge desert west of the end of the Hale River, Simpson Desert. Photograph from 3400 feet.

the terrible sand ridges of the Great Sandy Desert, as he named it. Crossing from Alice Springs to the Oakover River, he traversed the north end of the desert. His map of the journey shows the sand ridges between Joanna Spring and the Oakover River running almost due northwest. He gives a trend of northwest by west in 20° 20′ S., 123° 10′ E., and a trend of west-northwest at the west margin of the desert, near the end of his journey; his map shows a trend of N 60° W near the Oakover River. These trends are more northerly than indicated on Figure 2. It is possible that the observations were not very exact owing to the desperate condition of the party at the end of the journey. Warburton's map shows a sand-ridge trend of N 72° W at Joanna Spring. This is consistent with Wells's observations of the ridges there and to the south. Clapp (see below) gives a general easterly trend for the ridges northwest of Joanna Spring. These later observations have induced me to give an almost due-westerly trend for the sand ridges in the northwest corner of the Great Sandy Desert and to

[16] P. E. Warburton: Journey across the Western Interior of Australia, edited by H. W. Bates London, 1875; *idem:* Colonel Warburton's Explorations, 1872–3: Diary of Colonel Warburton's Exploring Expedition to Western Australia in 1872–3, *South Australia Parliamentary Paper No. 28*, 1875.

depart somewhat from the trends shown on Warburton's map in latitude 21°, making them some 10° more westerly.

F. G. Clapp entered the Great Sandy Desert from Jurgurra Creek, a tributary of the Fitzroy River, northwest of Joanna Spring. He attempted to take a motor vehicle across the sand ridges and succeeded

FIG. 14—The northwestern margin of the Simpson Desert. The sand ridges end against this range, 90 miles southeast of Alice Springs. View looking northeast from 3800 feet. The Todd River passes the eastern end of this range.

in doing so for 40 miles, crossing in that distance about 85 sand ridges.[17] He was in the sand ridges in longitude 123° E. between latitudes 19° and 19° 30′ S. The trend of the ridges there ranged from N 75° E to S 75° E. Clapp says that they were sometimes 60 feet high and 1000 feet wide and were from 1½ miles apart to four to the mile; they thus agree closely with the sand ridges of the Simpson Desert except in direction.

One of the most arduous and terrible journeys ever made in this desert was that of L. A. Wells,[18] who passed up its west side from Wiluna to the Fitzroy River, crossing the sand ridges at right angles the whole way. He gives the trend of the ridges as west-northwest throughout. He says that they were 100 feet high in 20° 30′ S., 123° 40′ E., and also mentions the same height in 23° 40′ S., 123° 20′ E.

Twenty-five years ago the Canning Stock Route was opened across

[17] F. G. Clapp: In the Northwest of the Australian Desert, *Geogr. Rev.*, Vol. 16, 1926, pp. 206–231.

[18] [L. A. Wells]: Journal of the Calvert Scientific Exploring Expedition, 1896–7, *Western Australia Parliamentary Paper No. 46*, 1902.

this desert from Wiluna to Hall's Creek, with wells at regular intervals. Talbot[19] gives a good account of the route, which does not seem to have been put to much use, if any. The cattle from the northwest are always sent down by cattle boat, a quicker proceeding, entailing less loss of condition. Talbot writes that at 17 miles from Weld Springs the stock route "enters sand ridge country." He recognized that the sand ridges were parallel to the southeast winter winds and that the ridges were not shifting. He says they were piled up against the east and southeast sides of ranges and that there were no sand ridges within two miles of the lee side. The flats between the ridges ranged in width from a few chains to a mile or more. He encountered the worst sand ridges on the southwest side of Lake Disappointment, in 23° 40′ S., 122° 20′ E. Between 21° and 22° S. and 125° and 126° E. there were 36 miles of very bad sand ridges.

The most extensive journey in this desert was that of the Hon. David W. Carnegie[20] in 1897. He traveled from Alexander Spring to Hall's Creek and returned to Alexander Spring by a more easterly route. He thus earned the unique distinction of having crossed the desert twice—up the center and down the east side—in one continuous expedition. The worst part of the journey was in the northeast corner of the desert, between Sturt Creek and Lake Macdonald. North of this lake he crossed 88 sand ridges in 8 hours of traveling by camel. The trend there he gives as east by north. The ridges were steeper on the north sides; their average height was 50 to 60 feet and their maximum height more than 100 feet.

The Mackay Aerial Expedition of 1930 covered all of the Great Sandy Desert east of the 128th meridian, from a base at the Ehrenberg Ranges. Commander Bennett was responsible for the aerial mapping. No account of this expedition has been published, but the map, showing the main sand ridges (one 130 miles long), is available at Canberra.

Giles's second crossing (1876), from the Gascoyne River to the Rawlinson Ranges, roughly along 24° 30′ S., was through the area he had already named Gibson's Desert in 1873, when one of his party, Gibson, perished in the attempt to go westward from the Rawlinson Ranges. Gibson Desert is the southern part of the Great Sandy Desert. Giles never had much to say about the sand ridges. His routes did not lie across them, which makes all the difference in the world to the traveler.

Origin and Mode of Formation of the Sand Ridges

The foregoing descriptions show that the sand dunes of the Australian deserts are everywhere longitudinal ridges, i.e. parallel to the

[19] H. W. B. Talbot: Geological Observations in the Country between Wiluna, Hall's Creek, and Tanami, *Western Australia Geol. Survey Bull. No. 39*, 1910.

[20] *Op. cit.*

direction of prevailing winds. The barchan, or crescentic dune, is practically unknown. It may possibly be found in some of the coastal dune areas of Australia, but it does not occur inland. The Australian sand ridges are low and straight and parallel, and the interridge areas are comparatively free from sand. There is no merging of crescentic or transverse dunes into the longitudinal type. The loose sand along the crests of the ridges may form small crescentic dunes that vary in shape with varying secondary winds, but in general the ridges have a remarkably uniform cross section and show little effect of superimposed forms. The ridges rise to a maximum height of 100 feet; the average height is 40 feet. Their average distance apart is a quarter of a mile; their length may reach hundreds of miles. They are fixed and covered with sparse vegetation, mainly spinifex. The only motion is in the direction of length. They tend to extend at one end and to be eroded at the other end. The trend is in general northwest, the direction of the trade winds, with a more westerly trend at both the north and the south margins of the western desert. The general movement of the sand is thus in a northwesterly direction along the length of the ridges. So much for actual observation, which raises the important questions of the origin of the sand and the mode of formation of the ridges. These two questions are probably closely connected. Other factors in the problem of sandy-desert topography are the strength and direction of winds and the relative aridity.

In some sandy deserts, as in Peru, the barchan, with its crescentic shape, convexity upwind, gentle slope upwind, and steeper slope downwind,[21] is the typical form of sand dune. In other deserts longitudinal ridges predominate—in the Indian Desert and in parts of the Sahara as well as in Australia. It seems certain that the longitudinal ridges occur only where there are strong dominant winds. Transverse sand ripples are universal in the form of little waves whose lengths are measured in inches, but large-scale transverse sand waves seem to be rare. Too much attention has perhaps been given to attempted comparison of the wind action on masses of sand and on the ocean. The water surface is level and the medium fluid. The movements of particles in the two cases are incomparable. The wind blowing over the surface of the land is not a steady stream but a turbulent current, full of eddies and endless vagaries, and the wonder is that there is any uniformity at all in the shapes assumed by the piled sand.

At the beginning of this article reference was made to Aufrère's intensive study of the forms of dunes in the African deserts, where there is almost every variety of sand formation. In a private communication M. Aufrère has informed me that his essential theory of the formation of longitudinal dunes is that they are derived from

[21] See Figure 21 (p. 21) in Robert Shippee: The "Great Wall of Peru" and Other Aerial Photographic Studies by the Shippee-Johnson Peruvian Expedition, *Geogr. Rev.*, Vol. 22, 1932, pp. 1–29.

forms similar to the *caoudeyres* of Gascony, which begin as wind-made excavations in the sand similar to the *fuljes* or horseshoe-shaped pits of the Nefud of Arabia and elsewhere. These excavations, accompanied by a piling of the excavated sand on the downwind side and a trail of sand left behind on each side of the excavation, extend downwind till they form a U-shaped dune, open to the windward, and, when the closed portion of the U disappears, become a pair of parallel dunes, longitudinal or parallel to the wind direction. Aufrère regards crescentic dunes, either of the barchan type, with convex side to windward, or of the *fulje* type, with concave side to windward, as probably an earlier stage in the evolution of longitudinal sand ridges.

Vaughan Cornish,[22] whose writings on wave formations are well known, seems to attack all problems from the starting point of transverse waves. In his earlier writings he derives the longitudinal ridges from series of transverse waves. Observations of sand ripples show that crests and saddles develop in them and tend to form in alignment in successive ripples over considerable distances in the direction of the wind. This principle is applied to large-scale transverse dunes: longitudinal ridges may be formed by "joining up the comparatively short residual longitudinal ridges left by the cutting through of the semi-consolidated transverse ridges."[23] The crests of transverse dunes form a series of arcs, with peaks and saddles. The saddles become complete breaches in the transverse dunes, and all the sand takes a position in the lines of the peaks; longitudinal dunes with wind-swept corridors between are thus formed. This seems reasonable; still there is no direct evidence that any such change from transverse to longitudinal dunes has taken place, nor is there evidence as far as is known that the process is going on at the present day. The *mer de sable* of the North African coasts is a sea of transverse waves; other deserts mentioned show nothing but longitudinal ridges.

The longitudinal ridges of the Grand Erg Oriental and Grand Erg Occidental are very complicated formations whose trend is difficult to determine except in an aerial view. They are often covered with transverse dunes and other superimposed forms and have not the straight and parallel appearance of the Australian sand ridges. They are long and somewhat irregular masses of sand rising to heights of 200 meters above the general level, as against the maximum of 100 feet of the Australian ridges, so that they are on a different scale altogether. Aufrère's illustration on page 380 of his "Cycle morphologique des dunes" is taken to be typical.

The sand ridges of the southwestern part of the Indian Desert, apart from their height, bear a much stronger resemblance to those of

[22] Vaughan Cornish: Waves of Sand and Snow and the Eddies Which Make Them, London, 1914.

[23] *Idem:* On the Observation of Desert Sand-Dunes, *Geogr. Journ.*, Vol. 31, 1908, pp. 400-402; reference on p. 401.

Australia.[24] The dunes in the Thar district of Sind have parallel sides and can be mapped as straight lines, with here and there a convergence. There are a few H-shaped dunes, which are wholly unknown in Australia. Farther to the northeast these become the dominant form and develop into transverse bars with several longitudinal projections on one or both sides, in the former case giving rise to "rake" forms. Enquist[25] regards the transverse dunes of the northern parts of the Indian Desert as fossil longitudinal dunes formed by an earlier, more prevalent northwest wind and later modified by the present wind system.

The longitudinal form of the ridges was ascribed by Blanford[26] to the particularly strong force of the winds, which blow for long periods at 30 miles an hour. The winds of the interior of Australia are gentle, rarely exceeding 20 miles an hour. Blanford considered that the Indian Desert was at one time much more thickly covered with sand and that the hollows between the sand ridges were due to denudation by the wind, so that the ridges would be residual rather than heaped up by the wind. This is an entirely different point of view, but it has much to recommend it could it be established that there had once been an accumulation of sand hundreds of feet thick. The conditions of origin of the sand appear to me to be the most important factor in determining the dune topography.

Aufrère is inclined to believe that there were originally in North Africa vast deposits of fluviatile sands left by the action of the Pleistocene rivers, the sand being the result of river erosion and not of insolation and wind action. The same might also apply to the sands of the Rann of Cutch, which possibly supplied a large proportion of the sands of the Indian Desert, where the net movement of the sand is inland. In the Simpson Desert in Australia, the flood plains of the Cooper and the Diamantina provide a similar possible source for fluviatile sands, and there again the sand is moving northwestward away from this source.

Wind action on an already deep sand deposit seems likely to produce transverse dunes, which may possibly develop into longitudinal dunes as deflation continues. I prefer, however, to trace the formation of longitudinal ridges from small beginnings, the ridges growing as insolation and disintegration provide the material. The inspiration for this idea was furnished by observations of drifting snow in the Antarctic. At the end of a blizzard, when the drift has almost ceased, the air has cleared, and the wind has dropped to perhaps 20 miles an

[24] Vaughan Cornish: On the Formation of Sand-Dunes, *Geogr. Journ.*, Vol. 9, 1897, pp. 278–309. A good reproduction of the longitudinal dunes of the Indian Desert is given on page 293.

[25] Fredrik Enquist: The Relation between Dune-Form and Wind-Direction, *Geol. Fören. i Stockholm Förhandl.*, Vol. 54, 1932, pp. 19–59; reference on pp. 54–55.

[26] H. B. Medlicott and W. T. Blanford: A Manual of the Geology of India, Parts 1 and 2, Calcutta, 1879; reference in Part 1, pp. 436–437.

hour, the surface drift may be watched. The little particles of ice are swept along over the hard ice or snow surface, the particles in temporary suspension rising to perhaps a foot or so above the surface. The surface drift is not an even sheet but is very obviously moving along as a series of little wavy rivulets of snow, with clear patches between, the rivulets being, of course, longitudinal. They have exactly the appearance, on a small scale, of the sand ridges at the southeast margin of the Simpson Desert, shown in Figure 6. The same thing may be noted, though not so conspicuously, in sand drifts when thin, loose sand is being blown over a level hard surface. When the wind drops, little lines of snow or sand must remain, and, if of sand, these are the nucleuses of longitudinal ridges. At any rate, a longitudinal arrangement is begun. This would tend to become established by the difference in the velocity of the wind over the immature ridges and in the interridge areas. The larger ridges would tend to straighten and to be augmented at the expense of the smaller. Fresh sand, either from further disintegration *in situ* or from a more distant source such as a delta or seacoast, would be added to the ridges, one side or the other of which would be a lee side as winds veered slightly, the new sand tending to avoid the more wind-swept interridge areas, where conditions are less favorable to deposition. In due course the longitudinal lines would be established and fixed in the direction of the prevailing wind. Cross winds would then only help to sweep up the intervening flats and make one side or the other of the ridges the steeper side.

In the deep snow fields of the Antarctic the consolidated snow becomes deeply channeled by longitudinal grooves with intervening ridges known as *zastrugi*. These *zastrugi* invariably indicate the direction of the prevailing winds and may be used as direction finders.[27] This longitudinal striation is imposed on already consolidated snow, or névé, and accords with Blanford's view of the grooving of the Thar out of a great thickness of sands. The *zastrugi* may be six feet high.

As regards the Thar, the Sahara, and the Australian sand-ridge deserts, the question is, was there ever a great thickness of unconsolidated sands over such wide areas? Areas of sandstone in them are known, but it seems probable that at least partial consolidation would have taken place before arid conditions could have become established. If that is the case, then it seems likely that the sand ridges in these great deserts have been built up as the material has been made available by the processes of disintegration. This is definitely indicated in the Australian deserts, where the sandstone mesas of the older peneplains still remain scattered throughout and the source of supply of the sand is still active. The ridges begin as many little wavy

[27] For example see Richard E. Byrd: The Flight to Marie Byrd Land; With a Description of the Map, by Harold E. Saunders, *Geogr. Rev.*, Vol. 23, 1933, pp. 177–209; reference on p. 203.

longitudinal lines and evolve into fewer and larger straight and parallel sand ridges.

This theory would require that a hard floor should be found under the sand ridges, at an even greater elevation than that of the flats between the ridges. Direct evidence of this is lacking, though it has often been suggested in literature. I have heard that horizontal beds of gypsum and limestone have been found under the sand ridges in the Lake Eyre country by travelers digging soaks for water on the edge of sand hills, and I have often been told that the sand is a relatively shallow veneer covering harder material in that area. An occasion will be sought to make an excavation in some of these ridges.

The general structure of the sand ridges of the Simpson Desert fits this theory very well. On the southeast or windward side the ridges are straggly and irregular, but they become straighter and exactly parallel farther in. There are no signs of transverse ridges. On the far side of the desert the sand ridges still retain their regularity and do not return again to the straggly form. This would also be the mode of formation when the source of supply of sand was not the whole sand-ridge area but was confined to a restricted area such as the flood plains of a river system. The sand ridges would then trail away from the source of the sand in longitudinal lines. It seems to me that the longitudinal is likelier to be a primary than a secondary form in most places. Transverse ridges might precede longitudinal ridges if the starting point were a sea of sand, which is considered improbable. It is possible that in time the ridges might grow till the whole area was covered and choked with sand, when transverse ridges might succeed the longitudinal ones.

The Simpson Desert gives the impression that there never was more loose sand present. Compared with the sand deposits of the Sahara, in both quantity of sand and size of the dunes, the Simpson Desert appears to be in a youthful stage of development, owing to lack of sand rather than to any consideration of duration of time. A balance has been reached in which the ridges do not grow. The supply of sand is equal to the demand of the gradual movement of all sand northwestward and of the loss by dust.

The remarkable uniformity and regularity of spacing of the sand ridges still remain a difficulty not altogether satisfactorily removed by any of the theories of the formation of longitudinal dunes.

THE WOOD YUKON EXPEDITION OF 1935*

AN EXPERIMENT IN PHOTOGRAPHIC MAPPING

Walter A. Wood
American Geographical Society

THE purpose of the Wood Yukon Expedition of 1935 was to carry out a piece of research in photographic mapping. The trend of photographic surveying, or photogrammetry, since its inception has been toward complex solutions to the problem of depicting topography. This trend has resulted in the development of plotting apparatus of high precision admirable for large-scale mapping but involving considerable expense. In the field of reconnaissance surveying, where maps on scales larger than 1:50,000 or even 1:100,000 require a basic network of triangulated points of a degree of accuracy surpassing that usually obtainable in unexplored country, the need has been felt for a method of survey embodying simplicity, economy, and accuracy.

For a number of years the Department of Technical Training of the American Geographical Society has been active in developing such a method, whereby high oblique aerial photographs are employed in the building up of topographic maps. This method was first used on the Grenfell-Forbes Expedition to northernmost Labrador in 1931.[1] During the course of the compilation of the resulting map the need for certain refinements and improvements in field technique became evident, and from it also came the idea of combining both ground and aerial photography and eliminating to a large extent the taking of measurements in the field. Thus the program of our expedition was to put into practice the experience gained from several years' work on the Labrador map.

The area selected was in southwestern Yukon Territory, immediately east of the international boundary between Alaska and Canada. It was chosen because of its mountainous character, ideal for the type of survey to be used; for its proximity to well established and easily identifiable control points—those of the International Boundary Commission's survey; for its relative accessibility; and because it was unmapped country.

Although the area was unmapped, the fringes of the high mountains had been visited and geological studies made on several of the streams

*In consideration of the mountainous character of the region, the expedition's personnel included six experienced mountaineers, Mr. I. Peace Hazard, Mr. Joseph W. Fobes, Mr. Harrison Wood, Mrs. Walter A. Wood, and the writer as leader, with Mr. Hans Fuhrer as guide. Miss Adeline Hazard accompanied a climbing party to one of its advance camps, and Mrs. Harrison Eustis journeyed to the expedition's advance base camp. In the carrying out of the scientific program the writer was assisted by Mrs. Wood and Mr. Harrison Wood.

[1] See the papers by Alexander Forbes, "Surveying in Northern Labrador," *Geogr. Rev.*, Vol. 22, 1932, pp. 30–60, and "A Flight to Cape Chidley, 1935," *ibid.*, Vol. 26, 1936, pp. 48–58.

FIG. 1

FIG. 2

FIG. 1—Whitehorse, Y. T. Head of steam navigation on the Yukon River (Lewes branch) and rail head of the White Pass and Yukon railway. The airport is on the bench above the town at right. (Day of month, time of day, and approximate altitude of plane are given for all aerial photographs. June 16; 8:23; 2900 feet.)

FIG. 2—Burwash Landing, expedition headquarters on Kluane Lake. (View from A on Fig. 3; Aug. 26; 16:15; 3300 feet.)

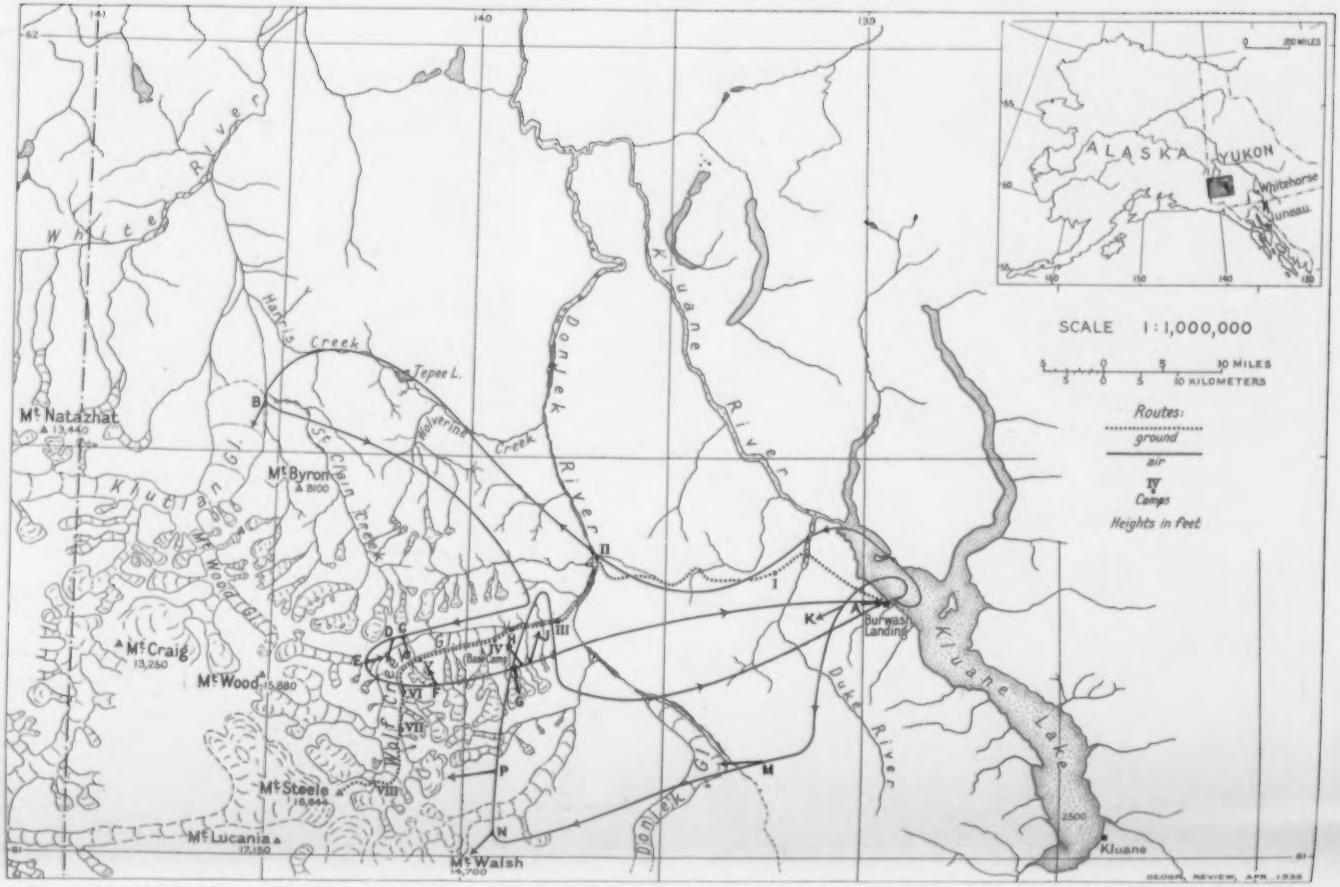


FIG. 1.—Map showing the routes of the expedition on the ground and in the air from the headquarters at Burwash Landing. The lettered arrows show direction in which the photographs illustrating the article were taken.

draining the landward slopes of the St. Elias Range. These studies were made early in the present century in connection with the exploitation of the Yukon's mineral resources, especially gold. Since that period the most notable scientific work in the region was the survey of the International Boundary Commission in 1913. During that survey the principal peaks of the area were recognized and their positions determined; but, as the boundary here passes to the west of the Yukon watershed, almost all the triangulation was executed on that side.

The area visited lies within the drainage basin of the White River, one of the principal tributaries of the Yukon, or, more precisely, in the basin of the Donjek River, which joins the White midway between its source and the Yukon. West of Kluane Lake, a body of water 40 miles long lying along the eastern base of the St. Elias Range, the character of the country changes from the rolling dissected upland of the Yukon plateau to excessively rugged country, abounding in swift-running streams draining the upper regions of perpetual snow. The area is bisected from south to north by the Donjek River, flowing in many braids over a flood plain from one to three miles wide and issuing from the glacier of the same name, whose feeding grounds are the snows of the St. Elias Range. Although many of the peaks of the region reach elevations of 12,000 feet, four are so prominent as to deserve special mention. They are Mt. Lucania, 17,150 feet, Mt. Walsh, 14,700 feet, Mt. Steele, 16,644 feet, and Mt. Wood, 15,885 feet, the last three lying on the watershed between the Yukon River and the glaciers draining into the Chitina River in Alaska.

First Flights

The expedition entered the field via Skagway, Alaska, and Whitehorse, Y. T., terminus of the White Pass and Yukon Railway, arriving at Whitehorse early in June. Arrangements had been made with the Northern Airways, Ltd., of Carcross, Y. T., to charter an airplane for the aerial work, and it was planned to execute the aerial photography before beginning ground operations. This procedure, which is contrary to the usual practice, was resolved on because points seemingly prominent from the ground are often indefinable from the air. It was hoped to make a reconnaissance flight at an early date, develop the negatives immediately, and fix the ground points with these as guide. Unfortunately, an unusually late spring held the winter ice in Kluane Lake until the middle of June. As we depended on the lake as a flying base, we were obliged either to make our flights from Whitehorse, 150 miles from the mountains, or to await the breaking up of the ice in Kluane Lake. Weather conditions suitable for photographic flying over high mountainous areas occur infrequently at best. Add to this the

FIG. 4

FIG. 5

FIG. 4—Meander of the Takhini River near Whitehorse, on the road to Kluane Lake. (June 12; 6:15; 5200 feet.)

FIG. 5—Kettle lakes in the Takhini Valley near Whitehorse. The floating timber in the lakes may indicate marginal slump from melting of underlying ice. (June 12; 6:25; 5000 feet.)

FIG. 6

FIG. 7

FIG. 6—The slightly entrenched meander belt of the Aishihik River, a tributary of the Dezadeash, looking north from a point above Canyon, Y. T. (June 16; 7:30; 8400 feet.)

FIG. 7—Meanders and oxbow lakes of the Dezadeash River at Champagne Landing, on the road between Whitehorse on Kluane Lake. The settlement is to the left of the meander in the foreground. (June 16; 6:50; 5600 feet.)

proximity of the ocean, and the chances of finding favorable conditions both over the snow peaks and at a base 150 miles away become small indeed. There is little question that, as far as atmospheric conditions are concerned, the winter months of January and February are most nearly ideal. The disadvantage of winter flying, in addition to extreme cold, is that many physical features essential in obtaining a correct physiographic interpretation of the topography are obliterated beneath a deep mantle of snow, and natural objects sufficiently defined for control purposes are similarly obscured.

Two flights from Whitehorse met with failure because of a cloud blanket overhanging the mountains, though on both occasions brilliant weather prevailed in the interior. Finally, word was received that Kluane Lake was ice-free, and operations were shifted to Burwash Landing, a small settlement near the north end of the lake. From here, after a week of bad weather, we were able to take off at four o'clock on a crystal-clear morning; and, when we had risen above the mountains bordering the west shore of the lake, we caught our first glimpse of the giant peaks of the St. Elias Range 50 miles to the west. Despite the auspicious start we were again doomed to failure. As our altitude increased, wisps of cloud became visible clinging to the valley walls and to the ice and snow-clad slopes of the higher peaks, and on approaching closer we found ourselves flying above a rapidly forming sea of clouds through which only the higher peaks protruded. Through occasional holes we caught glimpses of glaciers and valleys and were even so fortunate as to select a possible route into the heart of the range, but for photography intended for mapping there was no possibility.

This flight ended our photographic program before the ground work. The airplane was needed at its base; and rather than await the chance of a spell of fine weather we turned our attention to preparations for the trip into the mountains.

By Ground to Wolf Creek

By the end of June all members of the party had gathered at Burwash Landing, the others having come overland by truck from Whitehorse with the supplies and equipment, and on July 1 we set out with 34 pack and saddle horses toward the Donjek Valley.

Two days were required to reach the Donjek; for, although the valley is only 30 miles from Kluane Lake, the trip was broken out of consideration for the heavily loaded horses, which wallowed at times to their girths in the marshy tundra. Once on the firm floor of the valley, we turned southward upstream and endeavored to find a ford. The Donjek is a typical glacial stream, carrying much silt and shifting its course almost hourly into myriad channels that may be fordable

one hour and impassable the next. Fortunately a good crossing was found early in the day, and no difficulty was experienced; yet three days later the returning pack train met with swimming water in three main channels.

Thus far we had followed in the footsteps of predecessors. The country abounds in game, and in recent years numerous hunting parties have visited the lower slopes of the mountains on both banks of the Donjek. Now we diverged from the beaten track and turned up a tributary valley entering the Donjek from the west. This valley bears the local name of Wolf Creek and is the third tributary valley north of the present snout of the Donjek Glacier, which flows into the trunk valley from the west and occupies the whole valley floor over a distance of several miles. Existing maps indicate that the Donjek Glacier is the trunk glacier of the Donjek Valley. This is erroneous. The glacier lies in a tributary valley, and only its snout emerges into the main valley. From the air it was ascertained that for about fifteen miles south of the Donjek Glacier the trunk valley is ice-free. Above this point a previously unrecorded glacier which heads in the snows of the St. Elias Range occupies the valley. Wolf Creek is a swift-running glacial stream heavily loaded with silt. It flows from a glacier, which, to conform to the local name of the valley, we referred to as Wolf Creek Glacier. Its terminus is about six miles from the Donjek Valley. The stream has built up a large fan at the entrance of the valley, though it is not of recent construction, being well covered with a mature growth of tall spruce.

Wolf Creek Glacier and Base Camp

On July 5 a base camp was established at an altitude of 4000 feet, just at timber line, above the snout of Wolf Creek Glacier and on its true right bank. While the pack train returned to Kluane Lake for additional supplies we had ample time for reconnaissance work in selecting the easiest route up the glacier. Our objective was to penetrate as far into the range as possible and while doing so to build up a network of fixed points from which the positions of air stations might be determined. From the latter new points outside the area would be intersected and thus the control extended over as wide an area as the photographs covered.

Existing maps show Wolf Creek Glacier draining the slopes of Mt. Lucania and flowing in an easterly direction between Mt. Wood and Mt. Steele, from each of which a tributary glacier joins it. However, instead of finding a straightforward route to the base of Mt. Lucania via the glacier we found Mt. Wood and Mt. Steele connected by a 12-mile ice-incrusted ridge whose lowest point cannot be less than 11,000 feet high (Fig. 19). The tributary glacier indicated

FIG. 8—The lower eight miles of Wolf Creek Glacier. The Donjek Valley lies in the distance at right angles to Wolf Creek. (View from E. Fig. 3. Aug. 26; 15:30; 11,500 feet.)

as flowing from Mt. Steele is in reality the main trunk of Wolf Creek Glacier, and that shown flowing from Mt. Wood reaches its terminus several miles short of the main ice stream. It had been hoped to ascend Mt. Lucania and establish a survey station on its summit. Difficulties in crossing the Steele-Wood ridge caused a change in the climbing objective, and Mt. Steele was selected as a worthy substitute. The surface of Wolf Creek Glacier could not, in its lower part at least, be used as an avenue of approach. From its source in the southeast face of Mt. Steele it is about twenty-five miles in length, and the lower half is stagnating (Fig. 8). Only where streams have cut down to the bed does ice appear. The remaining surface is covered with a mantle of morainal material. In appearance it suggests a long succession of refuse dumps. No courses of medial moraines could be defined either from the ground or from the air, so dissected is the glacier by water action. Dams are constantly being formed by detritus slipping from the steep walls of the streams, only to break and continue the disintegration of what must once have been a fine ice stream. Near the snout two tributary streams, one from the north, the other from the south, have worn away the ice and built out alluvial fans that completely separate the terminus from the trunk.

We therefore followed the true right bank of the glacier. Although the going was rough in the extreme (Fig. 14), we were able, by constructing a trail, to push the pack train some ten miles above the base camp to a point where the glacier makes a sharp bend from a northerly to an easterly course. Here a tributary glacier joins the main ice stream from the southeast and effectively blocks horse transport. A depression between the right lateral moraine of Wolf Creek Glacier and the valley wall afforded an excellent camp site (Fig. 15). This was the first place up the glacier where horse fodder was available. A few minutes' walk downstream brought one to a grove of willows.

FIG. 9—Lower portion of the Klutlan Glacier. The international boundary between Alaska and Canada passes over the peaks in the middle distance. The lakes in the foreground are enclosed by moraine-covered ice. (View from B, Fig. 3. Aug. 25; 15:05; 10,500 feet.)

While pushing forward to the advance base camp we had been dogged with bad weather, prohibiting any attempt to climb summits for topographical purposes. Now on the threshold of the great peaks we were blessed with a succession of fine days, during which survey operations were carried on by the writer and his assistants while others of the party worked forward up the glacier and established a camp midway to Mt. Steele.

Wolf Creek Glacier below the bend flows through a valley flanked by steep walls. The northern wall rises precipitously in a series of horizontally bedded rocks perhaps three thousand feet thick (Figs. 11 and 13). Although we did not visit them, they appear to be composed of sedimentaries and igneous effusives. The waters of only two small glaciers drain into Wolf Creek from the north. Both lie in hanging valleys well above the main glacier and have retreated almost to the small ice fields that feed them. The south slope is gentler and of a different geological composition (Fig. 14). It shows massive igneous rock in the places actually examined. Eight glaciers drain into Wolf Creek from the south between the bend in the main ice stream and the Donjek Valley, and there are numerous small ice fields. None of these glaciers actually join Wolf Creek Glacier, their snouts being on an average a mile and a half to the south and ranging in altitude above the trunk glacier from a few hundred feet to about two thousand feet.

Above the bend the topography becomes more open. To the east the glacier is flanked by peaks gradually increasing in height toward the south. To the west a low ice-capped area forms a divide between Wolf Creek Glacier and two tributary ice streams draining the watershed between Mt. Wood and Mt. Steele. From the advance base camp, or, as it became better known, Camp 6, we were about eleven miles in a direct line from Mt. Steele, which towered more than 10,000

FIG. 10—Looking northeast over Wolf Creek, a braided stream typical of the region, to the Donjek Valley. (View from J, Fig. 3. Aug. 26; 15:45; 10,400 feet.)

FIG. 11—Horizontally bedded rocks of the northw... Wolf Creek Glacier. The height of the wall is ca. 350... (View from H, Fig. 3. Aug. 26; 15:43; 10,500 feet.)

FIG. 12—Looking eastward towards Mt. Walsh (left), Mt. Lucania, and Mt. Steele. The Donjek Valley lies behind the snow peaks in the foreground. (View from K, Fig. 3. June 21; 5:50; 12,500 feet.)

f the north wa
ll is ca. 3500
10,500 feet.)

g. 13—Looking over north wall of Wolf Creek Glacier above bend. In distance valley of St. Clair Creek. from F, Fig. 3. Aug. 25; 15:35; 11,300 feet.)

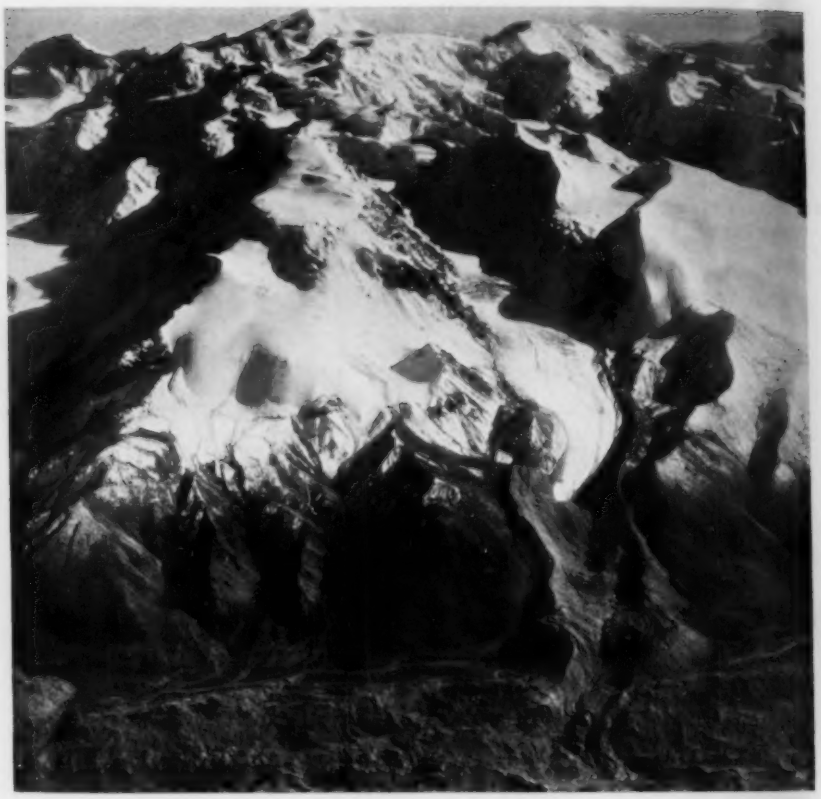


FIG. 14—Looking over the south wall of Wolf Creek Glacier just below the bend. The pack train passed along the upper margin of the morainal material seen in the foreground. Mt. Walsh (14,700 feet) in the background. Distance from snout of tributary glacier to front of its terminal moraine about a mile. (View from C, Fig. 3. Aug. 26; 15:25; 11,500 feet.)

feet above us at what appeared to be the head of the glacier, though the lower slopes were hidden.

ASCENT OF MT. STEELE[2]

During the week following the establishment of Camp 6 supplies and equipment were backpacked toward the mountain, and Camp 7 was pitched on the true right bank of the glacier midway between Camp 6 and Mt. Steele. On July 25 Hans Fuhrer and the writer pushed on from Camp 7 and after rounding the end of the intervening ridge had our first view of Mt. Steele from its summit to the glaciers at its base, a vertical interval of more than 9000 feet. We continued on and pitched Camp 8 at the foot of the east ridge where a large tributary glacier enters Wolf Creek Glacier from the northwest. The altitude of this camp was about 7200 feet. The following day more

[2] For a detailed account of the ascent see *Amer. Alpine Journ.*, Vol. 2, No. 4, 1936.

FIG. 15—Mt. Steele and the middle portion of Wolf Creek Glacier. Camp 6 was located at the lower left of the photograph between the right lateral moraine of the glacier and the mountain slope. (View from D, Fig. 3. Aug. 26; 15:28; 11,500 feet.)

equipment was brought forward, and Camp 8 was occupied by Messrs. Hazard, Fobes, H. Wood, Fuhrer, and the writer. The abnormally bad weather that had prevailed along the northern Pacific coast during the summer now resumed its attempts to drive us out of the region, and rather than consume food destined for an attack on Mt. Steele we retreated to Camp 6. Two more advances during the next week met the same fate but served the purpose of stocking Camp 8 with enough food for four men for two weeks. On August 8 the weather cleared suddenly, and shortly after midnight on August 9 we set out to attempt the mountain. Recent snowfalls made for slow and tedious progress, and at an altitude of 13,250 feet a violent storm descended upon us and forced a retreat to Camp 8. The storm reached blizzard proportions and continued for four days with the exception of a few hours on August 11, when we seized the opportunity to occupy a survey station above camp. During the four-day period 42 inches of snow fell at Camp 8. August 14 broke clear and cold, and we set out to establish another survey station as high as we could. To our surprise

we found the east ridge in far better condition than on our previous visit, and on reaching 11,000 feet we selected a prominent shoulder for the station (Fig. 20). The fine weather and excellent snow conditions decided us to make one more attempt on Mt. Steele. We left camp at 1.15 a. m. on August 15. The night was cold and brilliantly clear. The minimum thermometer at the survey station registered −4° F. Occasionally drifted powder snow slowed us down; but the

FIG. 16—Sea of clouds over the St. Elias range. Mt. Lucania (left) and Mt. Steele as seen from the east, about 40 miles distant. The peaks in the foreground overlook the Donjek Glacier. (View from M, Fig. 3. June 21; 5:23; 13,300 feet.)

greater part of the east ridge offered a firm surface, and shortly before noon we reached the plateau below the summit cone. This plateau is actually a shallow trough about 1000 feet wide running from northwest to southeast. Its lower end overhangs the abrupt cirque forming the head of Wolf Creek Glacier, and the lateral overflow of ice cascades down the great northeast face of Mt. Steele, well seen from Camp 6. A tedious hour in waist-deep powder snow brought us to the final slopes, and at 4.30 p. m. we stepped out on the summit.

We had been more than fortunate in having one of the few cloudless days of the entire summer on which to make the climb, and we had been further blessed with a windless day. The meteorological record shows that out of 28 days Mt. Steele was invisible for the greater part of 18 days, and on only one day was the mountain apparently free from blowing snow. The temperature on the summit was +15° F., and after completing a panorama of photographs for survey purposes and an all too brief study of the magnificent view that Mt. Steele affords we hurried downward and at 7.15 p. m. arrived in Camp 8.

August 17 found us again in Camp 6, and, after two more survey stations had been occupied, we left the region August 19 and arrived at Burwash Landing on Kluane Lake on August 23.

Completion of Aerial Program

Although ground operations were now completed, the aerial program had yet to be finished. Unfortunately the airplane arrived from

Fig. 17—Peaks of the St. Elias Range to the south of Wolf Creek, looking southeast. Note the accordant summit level, about 10,500 to 11,000 feet. (View from A, Fig. 3. Aug. 26; 15:40; 11,000 feet.)

Carcross too late to profit by two brilliantly clear days, but on August 26 we were able to take off early in the afternoon. Gaining altitude slowly, we flew across the low divide to the Donjek Valley and then bore northwestward, hoping to gain altitude in the face of a fair breeze from that direction. When we reached the Klutlan Glacier we had gained only 8000 feet—an hour's flight—and were at an altitude of 10,500 feet. We turned southward and skirted two 11,000-foot peaks standing isolated midway between Wolf Creek and the Klutlan Glacier, and at the mouth of Wolf Creek we turned westward toward Mt. Wood. To the south a storm was moving toward us from the ocean, and already Mt. Logan and the southern peaks of the St. Elias Range were engulfed in clouds. We had hoped to cross the Steele-Wood ridge and to circle Mt. Lucania and Mt. Steele, but the weather and the plane's stubborn refusal to gain altitude forbade this. A few miles short of Mt. Wood we circled and passed over the spot where Camp 6 had been and then sped home over the peaks south of Wolf Creek.

FIG. 18—Panorama from Camp 6, about 5500 feet. In the foreground the stagnant mass of Wolf Creek Glac

FIG. 19—Panorama from survey station 4, about 7000 feet, above the bend of Wolf Creek Glacier. Mt. Steel in center of left half.

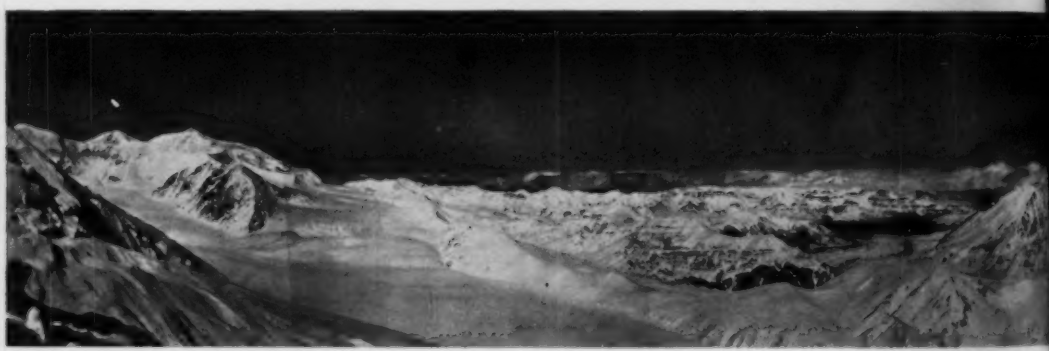


FIG. 20—Panorama from about 11,000 feet on Mt. Steele. At extreme left Mt. Wood, 15,000 feet. Left of cente Wolf Creek Glacier.

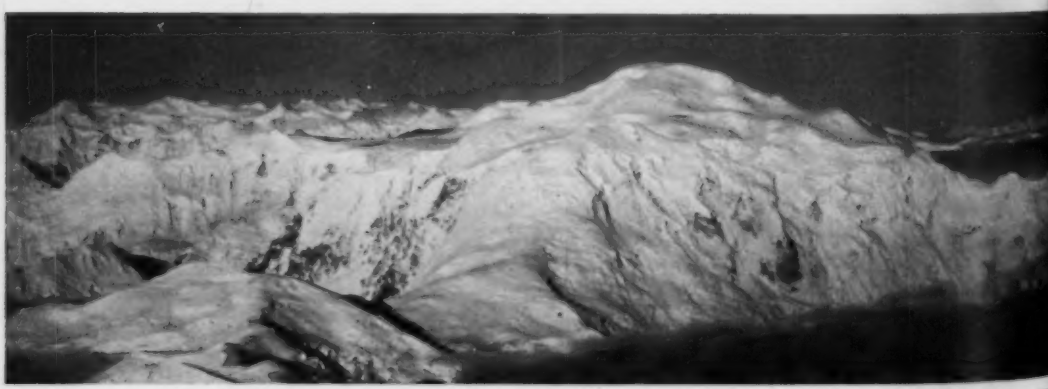


FIG. 21—Mt. Logan (distant left) and Mt. Walsh from the northeast. (View from N, Fig. 3. June 21: 5 13,200 feet.)

FIG. 18 (cont'd)—Scope of panorama is from south through northwest. (July 25; 10:15.)

FIG. 19 (cont'd)—Mt. Wood at left of right-hand half. Scope of panorama from south-southeast through north. (July 25; 17:45.)

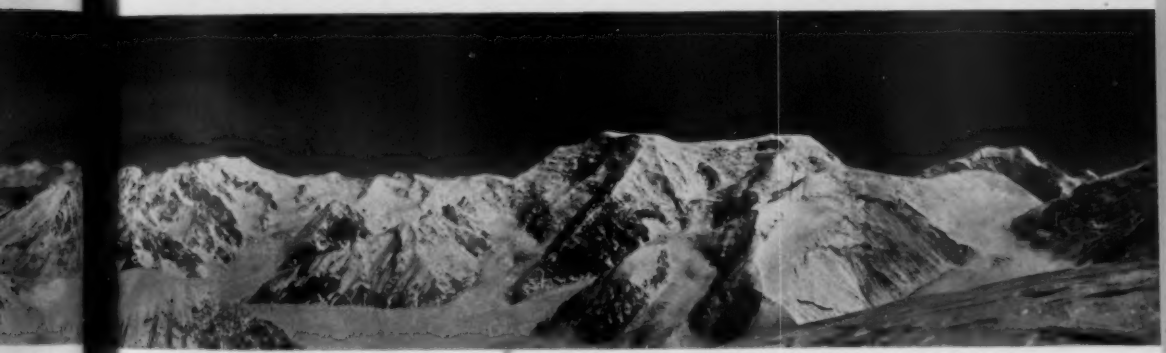


FIG. 20 (cont'd)—At extreme right in distance Mt. Walsh. 14,700 feet. Scope of panorama is from northwest through southeast. (Aug. 14; 12:15.)

FIG. 22—Mt. Lucania (left; 17,150 feet) and Mt. Steele (16,644 feet) from the east. (View from P, Fig. 3. June 21; 5:23; 13,500 feet.)

About 150 photographs were exposed and will be used in the construction of the map of the area on a probable scale of 1:100,000. An examination of the positives shows that enough of the points determined by the International Boundary Commission's survey are identifiable to permit the extension of control into the Wolf Creek area independently of the ground survey. Although the material collected is adequate for the construction of a map demonstrating the method employed, it falls short of the anticipated scope of the program as far as extent in area is concerned. This is due primarily to the unfavorable flying conditions experienced at the outset. It is hoped therefore that we may return to the same region during the summer of 1936 and, in addition to completing the mapping program, carry out investigations on several of the glaciers draining into the Donjek Valley, studies that the 1935 expedition was not equipped to perform.

During the ground operations standard meteorological observations were recorded daily. The observations included periodic readings of a compensated aneroid barometer, maximum and minimum thermometers, and wet and dry-bulb thermometers. A record of wind directions and percentage of cloud covering was also kept throughout the field season. Unfortunately the wet-bulb thermometer was broken near the outset, and observations for relative humidity were consequently discontinued. This breakage, it might be mentioned, was the only damage suffered by the scientific equipment, which in addition to meteorological instruments included two survey cameras, a Fairchild aerial F-8 camera, kindly lent the expedition by Mr. Bradford Washburn, a Wild Universal Theodolite and accessories, and prismatic compasses, the last two lent by the American Geographical Society.

Fine weather was enjoyed during only about half of the time in the field. According to the consensus of local opinion the season of 1935 was the worst experienced since 1898 over the entire Yukon basin. Kluane Lake, covering an area of 175 square miles, rose more than a foot in the six weeks between July 1 and the middle of August.

The question of winter flying has been referred to earlier in this paper; but if aerial photography forms a part of any program, it cannot be too fully emphasized that flying in the Yukon at present is expensive, increasingly so if unfavorable weather is encountered. If the flying program is an extensive one, it appears, on paper at least, that the investment in a secondhand airplane would materially reduce flying costs, since, with a pay load of 1000 pounds on pontoons, it should be able to transport equipment and supplies from the Pacific coast to an available base far more inexpensively than can be done by rail, truck, and pack train, and in a fraction of the time. Under such conditions the plane would be available to grasp the first opportunity the weather affords.

THE SPECIALIZED COMMERCIAL AGRICULTURE OF THE NORTHERN SANTA CLARA VALLEY

Edward N. Torbert

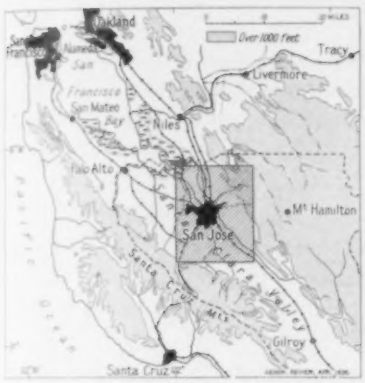


FIG. 1.—Map showing the situation of the Santa Clara Valley. Santa Clara County is defined by a dashed line. Scale 1 : 2,000,000.

The Santa Clara Valley is one of a number of waste-filled depressions, large and small, in which major farm industries of California are centered. In common with other districts, it is the seat of an intensive, commercial agriculture that is marked by a high degree of specialization. The main features of the valley and its utilization may be seen from a vantage point in the foothills. The intensively cultivated valley bottom, which has been aggraded and smoothly floored with alluvium washed from the mountainous blocks that bound the depression on the northeast and southwest, has a maximum width of about fifteen miles. At the northwest margin are a broad fringe of tidal marsh and, beyond, the southern arm of San Francisco Bay. About eighteen miles southeast of the bay the valley floor is abruptly narrowed by a group of low, grass-covered hills. The depression extends fifty miles beyond, but the field of this investigation is limited to the northern portion.[1]

From the west the valley floor seems completely carpeted with orchard. Its great extent and formal, carefully groomed appearance reflect the combined efforts of a relatively arge population whose presence is suggested by numerous rural dwellings, the closely knit road system, several small service centers, and the local metropolis of San Jose, midway across the valley. It is not surprising to learn that orchards occupy more than 60 per cent of all cropped land in Santa Clara County and that nearly three-fourths of the farmers of the county obtain their principal income from the sale of fruit.

This great orchard is made up of comparatively few different kinds of trees—a fact that is apparent late in March. At that season two-thirds of the trees display the same white blossoms; for the prune trees are in bloom—six million of them. Here and there on the margins of the valley the expanse of white is broken by rectangles of light green: these are apricot orchards that have blossomed earlier and now are in leaf. Together, prunes and apricots constitute about 84 per

[1] For a treatment of the evolution of land utilization in the entire Santa Clara Valley see J. O. M. Broek: The Santa Clara Valley, California: A Study in Landscape Changes, Utrecht, 1932.

cent of all the orchard trees. Pear trees, not easily distinguished from a distance, make up nearly 60 per cent of the remainder.

Local variation in the pattern may be discerned. Although seemingly coextensive with the valley floor when seen from the west, the orchard area farther east and north is broken by relatively large blocks of open land used for hay, pasturage, or truck. Within the orchard area, apricot trees are most numerous in a piedmont belt, and the bulk of the pear acreage is found on lower lands that lie closer to the bay. Utilization of the opposing foothill slopes also differs. A patchwork of orchard and open field rises well up the northeast side of the valley, but the opposite wall is largely clothed in woodland.

From this broad survey three phases of agricultural specialization in the northern Santa Clara Valley may be recognized: first, the dominance of horticulture; second, the emphasis on prune and apricot production; and third, areal specialization. A fourth characteristic is a well marked specialization on individual holdings.

Climate and Horticulture

The Santa Clara Valley enjoys a modified Mediterranean type of climate, excellent for the production of many deciduous fruits. The valley is partially shielded from the cool breezes and fogs of the coast by the Santa Cruz Mountains, and is shut off from the extremes of the great interior valley by the Mt. Hamilton Range (see Fig. 1). Winter weather is neither so warm as to impair the productivity of deciduous fruit trees nor so cold as to cause damage to them. During the summer the weather is sufficiently hot to ensure the ripening of fruit with a high sugar content, but not so hot as to cause injury to the crop. Sunshine is requisite for the production of fruit of the highest quality, and the Santa Clara Valley, with 82.4 per cent of the total possible amount of sunshine from June to September inclusive, is adequately endowed in this respect. The comparatively low relative humidity retards the growth of fungus diseases and facilitates the open-air drying of fruit. When to these advantages of climate are added others inherent in the large bodies of fertile, alluvial soil and in the availability of ground water that can be lifted by pumps and applied during the rainless summer in amounts and at times best suited to the needs of orchard trees, it becomes apparent that specialization in fruit culture has a sound environmental foundation.

The importance of the prune and apricot industries may be attributed, in part, to advantages of an early start and of large-scale production. It was in the Santa Clara Valley that the California prune industry was first established after Louis Pellier, in 1856, brought scions from the prune of the Agen district in France to San Jose. The Agen variety remains the great commercial prune of California, and

about 42 per cent of the total prune acreage of the state is found within Santa Clara County. Apricots were grown as early as 1792 at the Mission Santa Clara de Asís, northwest of the site of San Jose. In the production of this fruit also the valley has attained an outstanding position; for Santa Clara County has more than twice the apricot acreage of any other county and about 22 per cent of the total area in apricots within the state. The production of prunes, apricots, and other fruits was attended by the growth of packing, canning, and marketing organizations, the presence of which, in turn, furthered the extension of fruit culture. Today the farmer may dispose of his produce within the county at one or more of no fewer than 40 canneries, 32 establishments at which dried fruit is packed, and several others at which fresh fruit is handled.

Areal Specialization

The greatest block of prune orchards lies along the west margin of the valley (Fig. 2) where, on well developed alluvial fans, large bodies of the well drained loams essential to prune, and also to apricot, production are found (Fig. 3). Elsewhere also on similar light, well drained soils prune and apricot trees are grown successfully: there are orchards of these trees on the fan northeast of San Jose, on the narrow piedmont slope farther south, and on the natural levees that flank the larger stream courses of the valley bottom. Prune and apricot growers conspicuously avoid the shallow basins south and east of San Jose. The surface drainage of these basins has been cut off by stream-built ridges, and finer sediments transported by winter floods in the past have settled in the basins to form very heavy, poorly drained soils of which the prune and apricot are not tolerant (Fig. 3). Likewise, a broad zone of fine-textured, low-lying soils landward from the tidal marshes of the bay has not been occupied by prune and apricot growers.

The greater part of the apricot acreage is found on higher parts of the piedmont alluvial fans and on adjacent foothill slopes where not only are the suitable soils found but where, also, the trees enjoy relative or absolute immunity from spring frosts. The months of March and April are of critical importance to the apricot; for even light frosts during the period when the tree is blossoming and the fruit is forming, although not harmful to the tree, may cause failure of the crop. The degree of immunity from frost during this period is related to the location of the orchard with respect to altitude and also to slope. The frost-free belt of the spring season reaches from an upper, undetermined altitude, at least as high as 1200 feet, down to a variable lower limit, which at some places falls below 200 feet. In addition to altitude, however, the slope is of importance: unless the

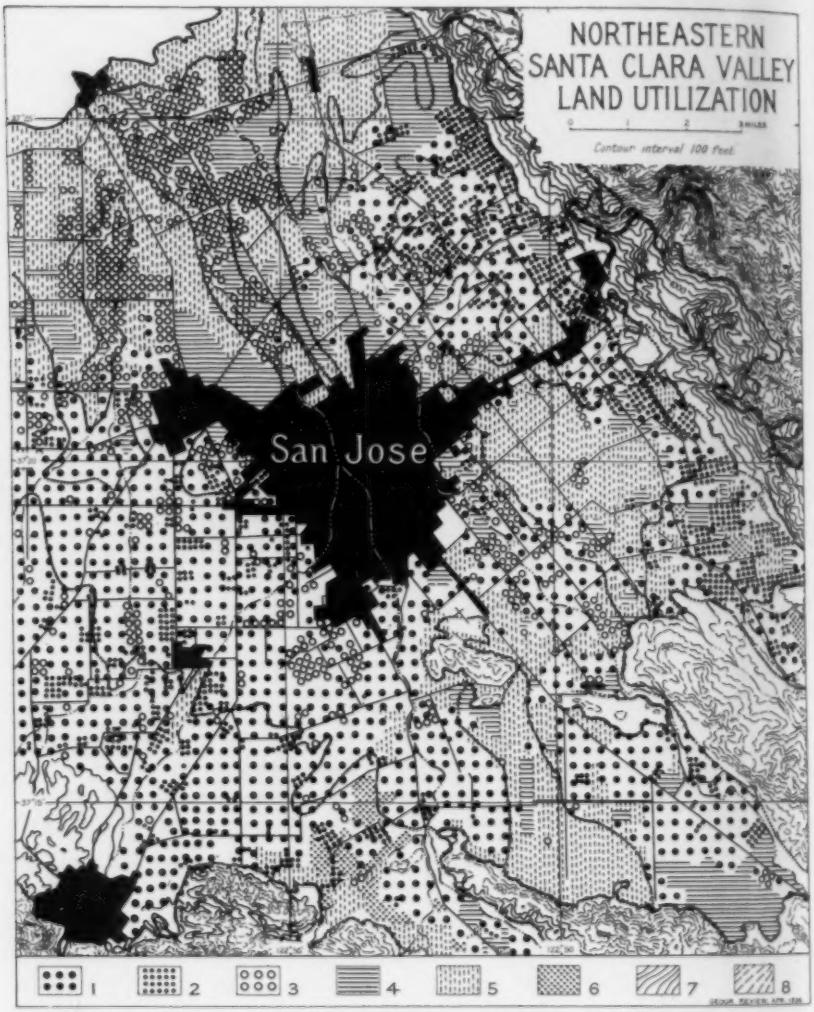


FIG. 2—Map of the northeastern part of the Santa Clara Valley showing land utilization. Legend: Valley floor: 1, prune orchard; 2, apricot orchard; 3, other orchard; 4, truck; 5, grass, hay, grain; 6, vineyard; Hill and mountain slopes: 7, cultivated; 8, pasture. Cities and villages are shown in solid black, paved roads by solid lines, streams by broken lines, soil boundaries by dotted lines. Contours after U. S. Geological Survey San Jose and New Almaden quadrangles; contour interval 100 feet.

Figure 2 was constructed from data obtained by the use of automobile odometers on traverses of all roads within the area mapped. The roads of the valley floor are so closely spaced that the use of this method permits a high degree of accuracy. (Much of the work on which Figures 2 and 8 are based was done by students of the writer.)

orchard is so situated as to permit the ready drainage of cold, heavy air to lower levels, smudging must be practiced. The average operating cost of heating a deciduous orchard is estimated to be $1.15 an acre an hour,[2] and on the lower edge of the piedmont slope east of

[2] W. R. Schoonover, R. W. Hodgson, and F. D. Young: Frost Protection in California Orchards, *Univ. of California College of Agriculture, Agric. Extension Service Circular 40*, Berkeley, 1930, p. 60.

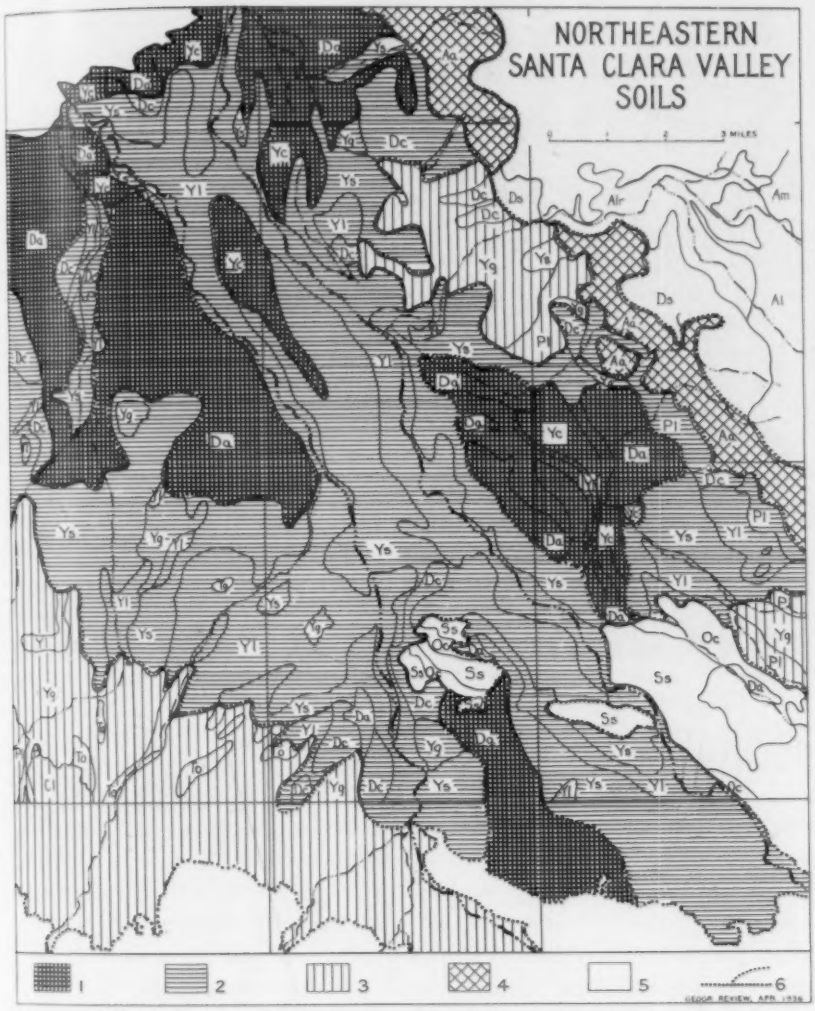


FIG. 3—Map of the northeastern part of the Santa Clara Valley showing soil types. Legend: 1, clay adobe and clays: Da, Dublin adobe; Yc, Yolo clays. 2, friable clay loams and loams: Dc, Dublin loams and clay loams; Ys, Yolo clay loams; Yl, Yolo loams; Pl, Pleasanton loam and gravelly loam. 3, gravelly loams: Yg, Yolo gravelly loams; Pl, Pleasanton loam and gravelly loam; Cl, Corning gravelly loam and loam (Dublin and Yolo series from recent alluvial material; Pleasanton and Corning series from coastal plain and old valley-filling material). 4, residual adobe: Aa, Altamont adobe. 5, other residual soils. 6, soil boundaries. Boundaries for individual soil types from L. C. Holmes and J. W. Nelson: Reconnoissance Soil Survey of the San Francisco Bay Region, California, Washington, 1917.

San Jose the operating costs of heating an apricot orchard may run as high as $50.00 an acre in a single season. In addition to this disadvantage, there are greater losses from jacket rot at lower levels. If ground fogs persist during the period when the fruit is forming and before the blossom jacket has fallen, large amounts of fruit may be lost by rot beneath the jacket. Although in these respects higher parts of the piedmont slopes are more satisfactory for apricots, the costs

FIG. 4—Apricot trees in blossom on upper piedmont alluvial slope.

of raising water for irrigation are greater than on lower lands; for in most areas the water table lies farther below the surface of upper alluvial slopes. At places the costs of raising water become prohibitive, and in the foothills steep slopes preclude irrigation, even if water were available. Without irrigation less fruit is obtained to a tree.

Much the greater part of the pear acreage, which constitutes 57 per cent of the orchard area in trees other than prune and apricot, lies in large, irregular tracts on low lands between San Jose and the bay. Most of the small area in apples is also found in this district. The frosts and fogs that make apricot production hazardous in this area are not a handicap to the growing of pears and apples, and the heavy-textured, relatively poorly drained soils, although ill suited to prunes and apricots, are well suited to pears. The growing of pears on these lands is favored by comparatively low irrigation costs; for the water table lies relatively close to the surface. The application of large amounts of water to soils that effectively retain it helps to make possible yields that, in at least one well managed pear orchard, are about seven times as great to an acre as the average for the state. Although heavy soils are occupied by pear growers, the extremely compact adobe and clay are difficult to work, and the pear orchards exhibit a well marked localization to the less compact soils, commonly underlain by heavier subsoils, that are found close to stream channels (Figs. 2 and 3).

Hay lands and pastures occupy considerable portions of the valley floor (Fig. 2). The leading crops are barley and oats—cut green for hay—and alfalfa. Some barley and wheat grain is produced, but the acreage in small grains harvested for threshing is less than one-fifth of the acreage cut for hay. In general these less intensively worked lands in hay and pasture may be considered as areas not well suited to orchard crops; they are roughly coextensive with the bodies of heavy, compact soils, many of which contain large quantities of alkali.

The production of milk for cities in the San Francisco Bay region is the dominant industry in the areas of hay and pasture, but subdivisions of activity may be recognized. Some dairymen grow all of the hay they require and purchase only grain feeds. Other dairymen grow no field crop of any kind and use a small plot of land merely as pasture and feed lot.[3] Other farmers, on lands well suited to alfalfa, keep no dairy stock but specialize in the production of alfalfa hay.

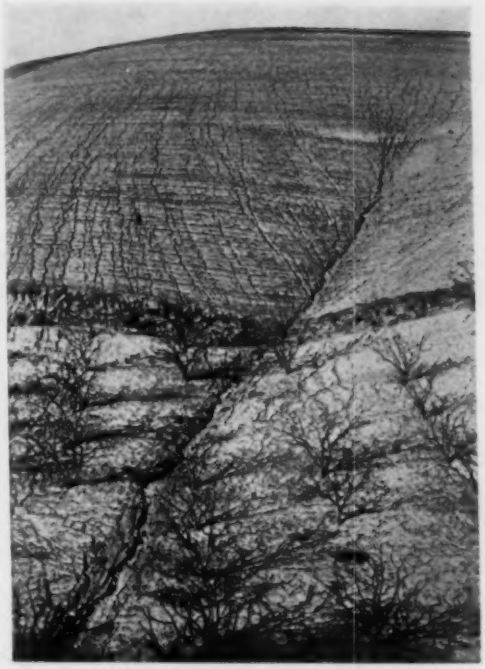


FIG. 5—Severe erosion on a slope in the western foothills.

Vegetables and small fruits occupy about 8 per cent of the cropland of the county (1929). Within the truck industry specialization in separate branches extends even to racial and national groups. The year-round growing of diversified truck crops engages the attention of many Japanese. The crops, in part, are sold in the San Francisco Bay region, but large shipments of fall, winter, and early-spring vegetables are made to eastern markets. The production of berries, chiefly strawberries and raspberries harvested during the summer, is almost entirely in the hands of Japanese. Another activity, which is somewhat less intensive and is not the specialty of any one racial group, is the production of crops for canning—spinach during the winter and tomatoes in summer. Tomatoes, however, which are the leading truck crop and which occupy about 40 per cent of the total vegetable acreage in the county, require more than three times the acreage used for spinach and also are grown on lands used for other winter truck crops and on some hay lands. Different from these branches of truck production, all of which are found on the valley floor and in all of which irrigation is employed, is the unirrigated spring-pea and corn production in the eastern foothills. This foothill zone, which will be discussed below, is as exclusively the province of the Portuguese as the berry fields are of the Japanese.

Vegetable growing has increased very rapidly during the past three

[3] Although the average size of dairy farms in Santa Clara County is 184 acres, the size of 36 per cent of the dairy farms in the county is between 10 and 49 acres inclusive.

decades, and the spread of the truck industry into suitable lands not previously occupied by orchardists helps to account for the somewhat scattered distribution of truck lands on the valley floor (Fig. 2). Vegetable growers have found the desired silty loams along the lower margins of some of the fruit districts, and in many other places heavier soils have been reclaimed by drainage projects.

Vineyards are the least important of the major classes of land

FIG. 6—The orchard landscape from the foothills southwest of San Jose, late in March.

utilization as far as area is concerned. Culture of wine varieties of grapes, the only types of any importance in the valley, has proved most successful on relatively coarse soils of older alluvial deposits. The only vineyards of importance within the area mapped lie on such gravelly soils at the south and east edges of the valley.

The eastern foothills support an agriculture different from that of the valley floor (Fig. 8). On the broken and rather broad belt of hills east and northeast of San Jose, where slopes are not excessively steep, there has developed a combination of prune and apricot production with the growing of early peas and corn. The unirrigated fruit trees are planted at wider intervals and do not reach so great a size as the irrigated trees of the valley floor. Peas planted beneath the trees in winter utilize what, in part, would be otherwise wasted runoff during winter and early-spring rains and mature before the trees are in full leaf. A large part of the peas, however, and most of the sweet corn, which matures about two months later than peas, are grown on lands not planted with trees. This eastern foothill belt of Santa Clara County and its northward extension in Alameda County constitute a leading spring-pea district of the state. For the years 1930–1934 inclusive one-quarter of the total California acreage

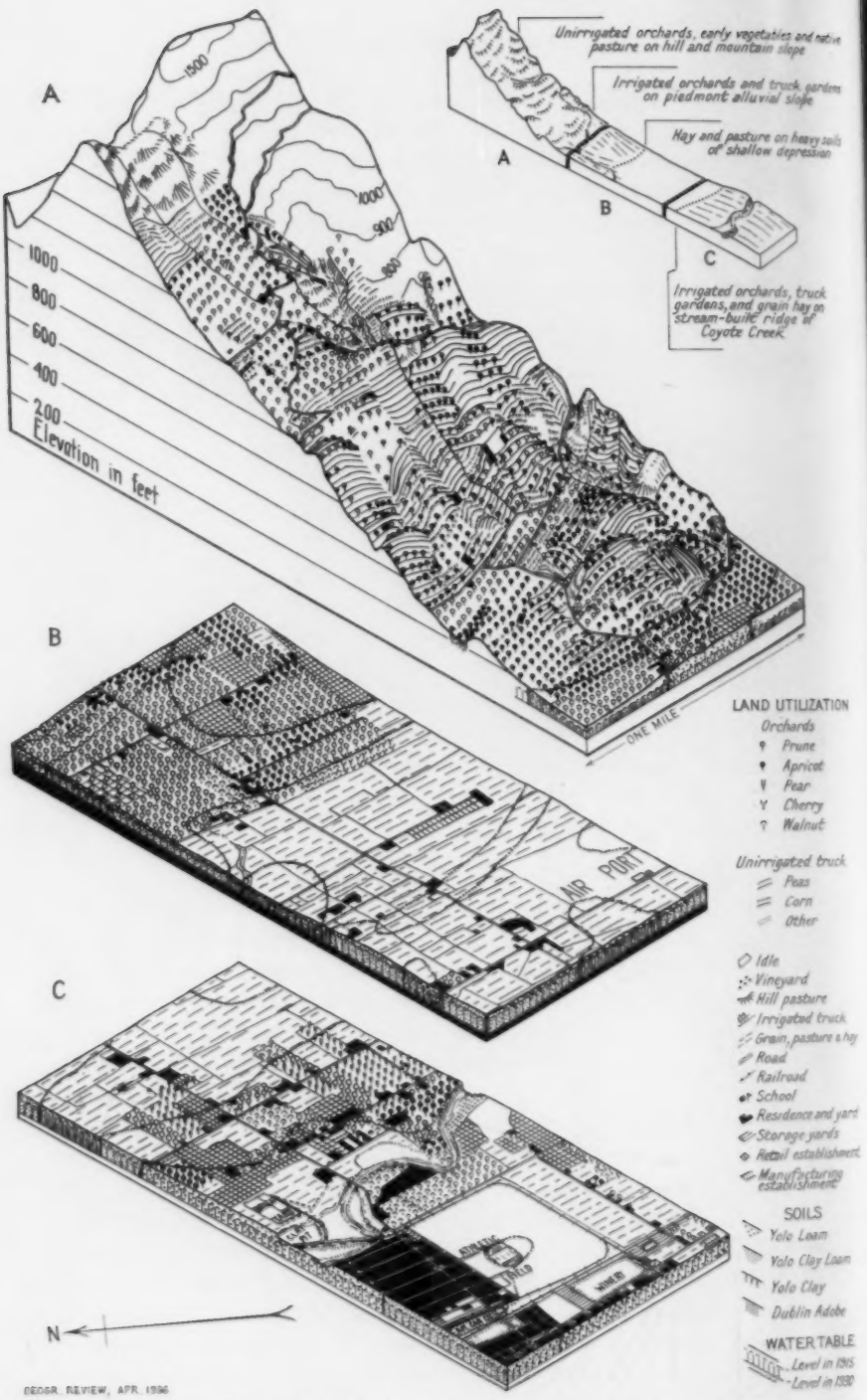
in spring peas was found within these two counties,[4] and from them were made 57 per cent of the total 2789 carlot shipments of green peas from California during the months of April and May, 1933.[5] The best development of this spring-pea and fruit-producing district is found on the relatively large areas underlain by residual adobe soils, which tend to be deeper, more retentive of moisture, and less subject to erosion than other, lighter soils of the foothill belt.

FIG. 7—Dairy lands of a shallow depression east of San Jose, irrigated orchards on the piedmont slope, and unirrigated orchard and vegetable belt on the eastern foothills. The higher slopes and the ranges beyond are sparsely populated by ranchers.

In contrast with the eastern foothills, the slopes at the west margin of the valley are little used for agriculture with the exception of some dissected bodies of old alluvium just above the valley floor. Slopes in the western foothills tend to be steeper than in the eastern belt; the soils are somewhat shallower and, inasmuch as they receive heavier precipitation, are more subject to erosion (Fig. 5). An additional factor that militates strongly against greater use of the western foothills is their exposure. The western hills face the north and northeast and so receive comparatively little insolation, whereas the opposite slopes—those used for early-pea production—obtain a maximum amount of heat, facing, as they do, the south and southwest. Not only does the smaller amount of insolation on the hills at the west margin of the valley make the production of an early crop impossible, but it also makes for the growth of woodland, which is more difficult and costly to bring into cultivation than the grassy slopes that face the sun. Hence, although the cultivated area is being extended on the eastern hills, the western foothills remain largely in woodland.

[4] California, Acreage of Specified Commercial Vegetable Crops by Counties, 1930–1934. Federal-State Crop Reporting Service, Sacramento, April, 1935.

[5] Car-Lot Shipments of Fruits and Vegetables in California during 1933. Market News Service. Bur. of Agricultural Economics, U. S. Dept. of Agriculture, Washington.



GEOGR. REVIEW, APR. 1936

FIG. 8—Detailed map-diagram of a mile-wide strip extending seven miles northeastward from the southern outskirts of San Jose to the crest of the first range. The map-diagram is effective in showing cultural adjustments to natural features, e.g. attention is called to the sharp division of orchard and hay lands along the boundary between clay loams and clays in Block B, to the greater extent of apricot orchards on higher lands, to the fact that north-facing slopes in the foothill belt have not been planted, and to the drop in the water table.

SEASONAL OPERATIONS ON REPRESENTATIVE FARMS

	FRUIT FARM ON THE VALLEY FLOOR	FARM IN THE EASTERN FOOTHILLS	TRUCK FARM
SIZE	Twenty acres; all cultivated land in prune trees, planted in 1893. (The average size of fruit farms in the county is 41 acres, but more than half of the fruit farms are of less than 20 acres.)	Thirty-four acres; 2½ acres in apricot trees, 13 in peas, 7¼ in corn, and 3 in hay.	Thirty-eight acres; 5 acres in house lot, garden, and buildings of owner, who lives on the property and rents cultivable land to Japanese; cultivable land all in vegetables except a small plot of pear, cherry, and walnut trees, the remnant of an orchard pulled up in 1924.
LABOR	Owner (of Danish descent), occasionally aided by son.	Owner (Portuguese immigrant of 1917) and three sons.	Two Japanese families and eight Filipinos hired by the Japanese. The Filipinos, unmarried men, live in a shack near the homes of the Japanese on an adjacent 20-acre tract, also worked by this group.
EQUIPMENT	House, barn, garage, chicken house, fruit shed, trays and boxes, 5-ton dehydrator, Fordson tractor, spray outfit, disk harrow, 100 chickens (providing additional cash income), well, centrifugal pump, 20-hp electric motor.	House, barn, shed for sulphuring apricots, two horses, one cow, plow, harrow, planter, cultivator, well (for domestic use only), suction pump, windmill.	Barns of a former dairy on adjacent tract, three small houses, caterpillar tractor, two horses, numerous implements for plowing, deep harrowing, preparing and planting seedbeds, and cultivating, well, centrifugal pump, electric motor.
SCHEDULE OF OPERATIONS Winter	*Prune:* begin in fall, continue all winter unless labor hired. *Spray* for San Jose brown scale; requires three or four weeks in January.	*Plow* land for truck crops. *Plant* peas (Nov., Dec.) and corn (Jan.). *Cultivate* peas and corn.	(Preparation of the ground, planting, irrigating, cultivating, and harvesting are carried on throughout year.) *Plant* lettuce, cauliflower, spinach, and parsley. *Harvest* broccoli, celery, sweet anise, cauliflower.
Spring	*Irrigate* (omitted during years of low prices). *Harrow under* cover crop. *Work* soil repeatedly.	*Cultivate, hoe,* and *thin* corn. *Spray* apricots. *Harvest* peas (25 to 40 pickers employed). *Pull* pea vines for stock feed, or harrow them under in apricot orchard.	*Plant* celery, snap beans, lima beans, cucumbers. *Harvest* lettuce, cauliflower, spinach, potatoes, parsley.
Summer	*Irrigate:* requires about three weeks, working days only. *Harrow* and *drag* soil repeatedly. *Dust* trees with sulphur at least once for red spider. *Work* on trees: dig around roots for suckers and borers; cut out and burn wood killed by prune beetle. *Prop* heavily laden trees.	*Harvest* corn. *Harvest* apricots. *Prepare* apricots: cut, pit, smoke with sulphur to improve color, and dry.	*Plant* celery, snap beans, peppers, lettuce, cauliflower. *Harvest* spinach, snap beans, lima beans, cucumbers.
Fall	*Harvest:* family of four employed during August and September. *Dry* and *sort* prunes. *Plant* leguminous cover crop. *Irrigate. Prune.*	*Harvest* cornstalks for cattle feed. *Prune* apricot trees.	*Plant* broccoli, cauliflower, sweet anise, potatoes. *Harvest* celery, cauliflower, snap beans, peppers, lettuce.

Specialization on Individual Holdings

Eleven kinds of fruit trees are recognized in the census report for Santa Clara County, but the average number of different kinds of trees to a farm on which fruit is produced is barely two.[6] The typical orchardist has no agricultural interest aside from his commercial specialties: he raises no field crop, he has no stock.[7] Vegetables are grown for home use on less than 15 per cent of all farms in the county.

Specialization on individual holdings is possible because the labor

Fig. 9—Cultivating peas for fall harvest on a dairy farm northeast of San Jose. After harvesting a crop of barley hay in the spring, the entire cultivable area (110 acres) was planted in peas and tomatoes.

of a farmer can be applied efficiently throughout the whole year to the production of a single commodity—a fact that is apparent from the accompanying outline of seasonal operations on a prune "ranch"—and also because an adequate market and marketing organization for that commodity are available. Specialization is desirable for a number of reasons: it minimizes fixed investments in special kinds of equipment; it permits the use of land for the crop to which it is best suited; it permits mastery of the complicated technique requisite to the production of fruits and vegetables of high quality—and only produce of high quality finds a satisfactory market.

Advantages the grower achieves through specialization are much to be desired; for many items of production and marketing costs are unavoidably high. Investments in wells, pumps, and motors are high. So are operating charges. Moreover, for reasons to be noted below, both are increasing. Wages for labor during the harvest season must be paid. Charges for transportation to distant markets, charges for

[6] The total number of farms reporting fruit trees in 1930 was 4971, and the sum of the farms reporting under each of the 11 classifications was 10,172.

[7] Cows are maintained on less than 15 per cent of the holdings classified in the census as fruit farms, and horses or mules are found on only 29 per cent of these farms.

handling perishable fruits and vegetables, and the expense attendant on the seasonal preparation but year-round distribution of less perishable canned and dried products make it costly to place the commodities of the valley in the hands of the ultimate consumer.

The Labor Problem

Although by careful management the labor of one or more persons may be so distributed throughout the year as to accomplish all cul-

Fig. 10—Truck lands north of San Jose in July. In the foreground celery for fall and winter harvest is being irrigated and worked by Japanese. The dark patches in the foothills, in part, are orchards and, in part, fields that have yielded a crop of spring peas and now are fallow.

tural operations, additional help is required during the harvest season. Harvest labor for fruits other than prunes is largely recruited locally. The harvesting of prunes and some vegetable crops requires more laborers than are locally available and, in large part, is done by migratory workers—by Mexicans, by Filipinos, and by Americans from other parts of the state. The costs of harvesting a crop constitute a large part of the total production costs.[8] Specialization in a single crop—and that a perishable one—makes its prompt harvesting of critical importance and gives to the laborer, whose annual income may be restricted to earnings during a few short harvest seasons, a potentially strong bargaining position. The use of this bargaining advantage is limited by lack of organization among seasonal laborers and by various restrictive measures; for the grower's interest finds strong support in a community so largely dependent on his prosperity. Never-

[8] The results of studies in Bartlett-pear orchards of California indicate that the costs of harvesting and handling the fruit constitute almost 25 per cent of the total costs of producing a ton of pears (Arthur Shultis: Bartlett Pear Orchard Management. *Univ. of California College of Agriculture, Agric. Extension Service Circular 78*, Berkeley, 1933, p. 40).

FIG. 11—The hill and mountain slopes near the southwestern edge of the valley floor, February.

theless, violence has attended some agricultural labor disputes, and the situation holds possibilities for further difficulties.

THE WATER CRISIS

Virtually all water applied to orchard and crop lands of the valley is obtained from wells, and an increase in the pumping draft from, roughly, 25,000 to 134,000 acre feet a year between 1915 and 1933 has resulted in a serious drain on the ground-water supply.[9] Except in the former artesian zone north and west of San Jose, the ground-water level receded 95 feet between the spring of 1915 and the spring of 1933. Deficiency of precipitation, which during the seventeen years after 1915 was subnormal in an amount equivalent to 2.25 full years of rainfall, hastened the drop of the water table to an unknown, although apparently very great, extent. Engineers are in agreement, however, that the increased pumping would have caused a substantial lowering of the ground-water level had precipitation and natural recharge been normal.[10]

The lowered water table has greatly increased irrigation costs through additional capital investments in wells, pumps, and motors and also through increased costs for power. On the valley-bottom fruit farm for which a schedule of operations is shown the capital costs in 1929 for a well, deepened from 115 to 365 feet, for a new pump, and for an electric motor with capacity double that of the one formerly used amounted to $5000. For the northern Santa Clara Valley it is probable that the capital costs of deepened wells and increased pumping installations necessary because of the drop in the water table have been greater than $6,000,000, and the amount of power required to lift water because of deepened wells is estimated to have

[9] Santa Clara Investigation, 1933, *California Dept. of Public Works, Division of Water Resources Bull. No. 42*, Sacramento, 1933, p. 11. The data presented in this section of the paper are for the Santa Clara Valley Water Conservation District, which includes most of the valley floor in northern Santa Clara Valley.

[10] *Ibid.*; and H. L. Haehl's report in "Report on Waste Water Salvage Project to the Board of Directors, Santa Clara Valley Water Conservation District," by F. H. Tibbetts, San Jose, October, 1931: reference on p. 73.

increased 268 per cent between 1921 and 1931.[11]

Belated steps are being taken to improve the situation. No appreciable amount of rainfall penetrates directly to the water table through ordinary soils of the valley floor, and solution of the problem of checking the fall of the water table without decreasing the amount of water used for irrigation lies in increasing the percolation through stream beds. Because of heavy winter rains and attendant flood periods only 38 per cent of the runoff of streams of the valley passes into underground reservoirs under natural conditions.[12] The remainder, that which flows into San Francisco Bay, is estimated to be considerably more than the average annual overdrain on ground water. Plans designed to salvage a part of the wasted runoff sufficiently great to ensure a gradual rise of the water table included:[13] temporary storage of floodwaters in detention reservoirs with a total capacity of 79,000 acre feet; the release of these waters to pervious stream beds at rates permitting complete absorption; spreading and percolating works on natural stream channels; check dams on watersheds unsuited to detention reservoirs; and a canal system to distribute salvaged waters from Coyote Creek, the largest stream of the valley, to areas of deficiency. An unfavorable vote in 1931 on the $6,000,000 bond issue essential to the execution of these plans was followed by submission of a modified scheme, one-third as costly, that obtained popular support in 1934. In the present project, which, it was hoped, would be completed by the winter of 1935–1936, the canal system to distribute waters from Coyote Creek and the mountain check dams are not included, and the storage capacity of detention reservoirs has been reduced from 79,000 to 49,750 acre feet. The extent to which the measures now being taken

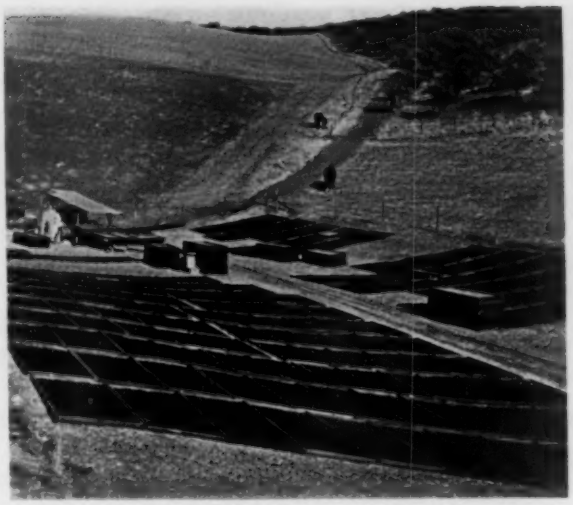


FIG. 12—Drying yard for a prune orchard in the eastern foothills. The entire prune crop of the valley is dried.

[11] Haehl, *op. cit.*, p. 77.

[12] Tibbetts, *op. cit.*, p. 8.

[13] That a satisfactory solution of the problem can be achieved seems to be indicated by the fact that during the years 1915–1916, 1920–1923, 1925–1927, and 1931–1932, when precipitation was normal or above normal, the water table under most parts of the valley rose slightly. See "Santa Clara Investigation" (*op. cit.*), p. 11.

will check the drop in the water table remains to be seen. Unless the drop is completely checked in the near future, large portions of the valley floor necessarily will be returned to less intensive uses. Indeed, even maintenance of the water table, if it is at a low level, may not suffice; for, in the long run, high irrigation costs may well place growers in the Santa Clara Valley at a serious disadvantage with growers in other districts where water may be obtained at less expense.

The Approach to Complete Development

In the northern Santa Clara Valley production of the great specialties of the valley, prunes and apricots, seems to have reached maximum development. From a peak of 66,763 acres in 1929 the area in bearing prune trees had declined 1586 acres by 1932, and the area in bearing apricot trees in 1932 was 357 acres smaller than the maximum of 18,248 acres in 1930.[14] Moreover, the ratio of nonbearing to bearing trees in 1932, for both prunes and apricots, was only about half that of 1930. Although production in excess of market capacity and the attendant depressed prices for fruits in general have discouraged planting, it is also true that the area well suited to prunes and apricots and not already planted with them or with other equally profitable trees is limited. Any increased planting of prunes and apricots in the foothills and on the open lands of the piedmont slopes will probably be offset by the removal of orchards, now in progress, on lower lands whose heavier soils have acquired submarginal value for the growing of these fruits. As to the minor tree crops that may be said to compete with prunes for the deep, well drained loams of the valley floor conditions differ. The area in bearing peach trees has decreased, but the areas of bearing plum, cherry, and walnut trees have shown increases coincident with, but equal to only 60 per cent of, the reduction in acreage of bearing prune, apricot, and peach orchards. Between 1929 and 1932 the area of the county in bearing pear trees was increased from 6292 to 7308 acres, but subsequent planting has been retarded by depressed prices for pears and also by the competition of truck growers for the most desirable soils.

The expansion of the truck industry is the outstanding development of the recent past and the present. The area[15] given to the leading truck crops of the county increased from 11,074 acres to 17,703 acres between 1929 and 1934. This extension has taken place, in some measure, upon lands from which orchards have been uprooted and, in greater measure, upon lands previously used for hay, grain, or pasture. The greater attractiveness to landowners of the rentals obtained from

[14] R. E. Blair: Acreage Estimates: California Fruit and Nut Crops, 1927 to 1932, *California Cooperative Crop Reporting Service Special Publ. No. 117*, Sacramento, 1932.

[15] The acreage for 1934 is from "California, Acreage of Specified Commercial Vegetable Crops" (*op. cit.*). The acreage of the same crops in 1929 is from the census of 1930.

truck growers than of the income derived from marginal orchards and from grasslands makes a continuance of the present trend seem probable. Displacement of any considerable part of the great orchard crops by truck seems highly improbable, however; for many of the orchard soils are less satisfactory for vegetables than the finer sediments, and the cost of irrigation, an item of great importance in truck gardening, in general is higher on the piedmont slopes than on lower lands. Moreover, granting a satisfactory solution of the water problem, it does not seem likely that the prune and apricot industry will be seriously imperiled by increased competition from other districts. There probably is no area with better natural endowments, with superior equipment, and with a more experienced body of orchardists for carrying on this industry than the northern Santa Clara Valley.

LAND-USE AND WATER-SUPPLY PROBLEMS IN SOUTHERN CALIFORNIA: MARKET GARDENS OF THE PALOS VERDES HILLS*

H. F. RAUP

University of California at Los Angeles

THE American appetite for green foodstuffs has grown to demand fresh lettuce, beans, celery, and other vegetables, regardless of weather conditions, as the possibilities of scientific refrigeration and fast transportation have developed. As a result, many of our larger centers of population are fringed with market gardens and hothouses that attempt to meet the demand, and some districts such as the southern Atlantic coastal plain and the Imperial and Santa Maria valleys of California have become "salad bowls," relying on rapid freight service to place their garden products on distant markets. Nevertheless, local sources of supply, near enough to the city to deliver the produce by truck, continue to be an important factor in supplying green goods for the urban diet.

The fertile plains surrounding the city limits of Los Angeles are used extensively for the production of garden vegetables for the local market. The field labor is largely in the hands of Japanese ranchers, who lease vacant lots or fields, lay out the garden patches, and ship their products into the city. Since the climate of Los Angeles is of the type in which summer drought is characteristic (Csa), irrigation is generally necessary.

In the ring of market gardens surrounding the city there is one area, however, in which conditions for growing are such that irrigation is unnecessary, except for an occasional light overhead sprinkling at irregular intervals during the early growing season of the plants. This area is known as the San Pedro Hills or the Palos Verdes Hills and lies 20 miles southwest of the city, on the shore of the Pacific. The profile of the hills presents a series of remarkably well preserved marine terraces, a result of successive uplifts so recent that erosion has had little opportunity to destroy the lower benches. The upper slopes and terraces have deep barrancas slashed through both bench and sea cliff, and their outlines are somewhat obscured. The formation of the benches is still in progress; for the sea has carved a 125-foot cliff almost entirely around the hills along the present strand line.[1]

Without the terraces the hill slopes would be too steep for successful

*Field work for this paper was made possible through a grant from the Board of Research of the University of California. A paper dealing with a related topic was published under the title "Land Use and Water Supply Problems in Southern California: The Case of the Perris Valley," *Geogr. Rev.*, Vol. 22, 1932, pp. 270–278.

[1] A thorough geomorphological study of these terraces, lacking only an adequate map, has been made by A. C. Lawson: The Post-Pliocene Diastrophism of the Coast of Southern California, *Univ. of California, Bull. Dept. of Geol.*, Vol. 1, 1893–1896, pp. 115–160.

agriculture, especially if frequent cultivation of the plants is necessary. The lower terraces slope gently seaward and give good drainage to the thin residual-soil cover that has developed upon them, and it is here that the growing of unirrigated vegetable crops has been profitable

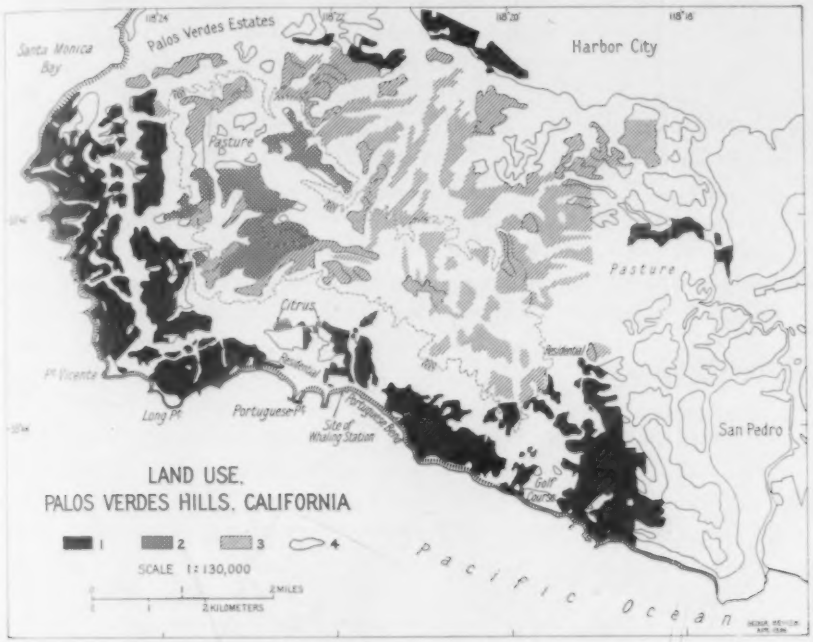


FIG. 1—Map of land utilization, Palos Verdes Hills, California. Legend: 1, fresh vegetables (peas, beans, squash, tomatoes, cucumbers); 2, dry vegetables (lima beans); 3, barley for grain or hay; 4, benches. Part of Los Angeles harbor is seen on the extreme east.

commercially. Most of the interterrace slopes are too steep for the plow and remain uncultivated, though occasionally even these slopes are farmed with difficulty.

CRITICAL CLIMATIC FACTORS

The vegetables produced here are comparatively few in variety and consist chiefly of tomatoes, cucumbers, string beans, summer squash, and peas, grown entirely for the Los Angeles market. Beans and peas are usually sown in December, shortly after the first soaking rain of the season; they grow during January, February, and March and may be marketed in early spring. Cucumbers are sown under muslin covers, in hotbeds, and occupy relatively little space on the slopes. Tomato plants, started in hotbeds, are set out in December and January. By February 1 the terraces are tinged with the green of the young plants, and by March 1, if the winter rains have not been deficient or delayed, the plants are six to eight inches high. The

amount and the time of rainfall are critical factors. In some seasons the entire planting is lost or is unprofitable because the rainfall came at the wrong time or was inadequate.

The average annual precipitation along the Palos Verdes coast is about ten inches, and this is apparently just enough rain, in combination with other climatic factors, to make possible the growing of perishable vegetables on the terraces. With this relatively small amount of rain, the coast approximates the steppe type of climate (BS).[2] Farther inland, at Los Angeles, irrigation of vegetables is commonly practiced, though the actual amount of rainfall is greater. On the Palos Verdes Hills the small amount of rainfall is augmented, however, for plants, by a relative humidity that usually is greater than that of the near-by parts of the Los Angeles area. The coastal location and the ocean breezes, reducing the effectiveness of evaporation, make possible a high relative humidity at Palos Verdes. This, however, does not imply excessive fogs; for in 1928, the foggiest year on record, it was necessary to use the whistle at the Point Vicente light a total of but 695 hours, or 8 per cent of the time. In 1931, an unusually warm and dry year, the fog warnings were in use only 152 hours, or 1 per cent of the time. Although dense fogs, dangerous to shipping, are not common on this coast, the effectiveness of evaporation is greatly reduced by a blue haze, characteristic of southern California, which acts to reduce insolation and evaporation of surface moisture.

The effect of the reduced evaporation is seen when the data for Point Vicente and Los Angeles are compared. Although both have about the same mean annual temperature—60° F.—Point Vicente has a range of 12.5° F. between the winter and summer monthly means, and Los Angeles has a range of 16.1° F. The slightly more equable temperatures that prevail at Point Vicente (warmest month 66.5° F.; at Los Angeles, 71.2° F.) have critical values for agriculture. Eleven-year records, from 1914 to 1925, give Point Vicente a mean relative humidity of 71.4 per cent; at noon in Los Angeles the humidity averages 51 per cent. The increment of air moisture at Palos Verdes[3]

[2] The records for Point Vicente indicate a BShs classification, but the factor of marine influence is not considered by the Köppen formulae. Thornthwaite's classification (The Climates of North America According to a New Classification, *Geogr. Rev.*, Vol. 21, 1931, pp. 633–655) attempts to include as climatic elements the effectiveness of precipitation and the efficiency of the temperature; this gives the Point Vicente area a semiarid mesothermal climate with summer deficiency of rain (DB's): yet this classification also remains unsatisfactory because of the increased precipitation effectiveness and reduced temperature efficiency due to an unconsidered factor—marine influence. The Thornthwaite climatic map assigns the same classification to San Bernardino and Santa Monica; actually there is a marked contrast in their climates, since the precipitation-evaporation ratio is necessarily higher in Santa Monica. The problem is discussed by W. T. M. Forbes: A Note on Thornthwaite's New Classification of Climates, *Geogr. Rev.*, Vol. 22, 1932, pp. 478–480.

Since the above was written a communication from Dr. Thornthwaite states that the summer concentration of thermal efficiency for Santa Monica is 28.6, whereas that for Santa Bernardino is 34.2; complete classification places Santa Monica as DB'sa, San Bernardino as DB'sb.—EDIT. NOTE.

[3] Temperature, rainfall, and humidity data for Los Angeles are taken from *U. S. Weather Bur. Bull. W*, 2nd edit., 1926, Vol. 1; for Palos Verdes, from observations made by Dr. Ford A. Carpenter from 1915 to 1925 and from records of the lighthouse keeper at Point Vicente.

is the controlling factor in the agriculture of the region; such agriculture without irrigation is not profitable commercially 20 miles inland. Cultivation of unirrigated vegetables on the coast, then, provides to a limited extent an empirical method of determining the extent of marine climatic influence in this vicinity.

The competition for the best prices for spring vegetables is keen. The enterprising farmer attempts to advance the date on which his vegetables may be marketed. Thus for tomatoes the method in use is to place around each plant a small paper cap, which has two functions: to preserve the moisture in the soil around the roots and to create a hothouse temperature. Each plant grows underneath its "hotcap," where the mean temperature averages 20° higher during the day than that of the outer air. As soon as the plant has filled the space beneath the cap, the cover is punctured on the south side, to permit the plant to grow

FIG. 2

FIG. 3

FIG. 4

FIG. 2—First terrace above the shore at Palos Verdes, showings the upper edge of the sea cliff in right foreground. Vegetables are planted on the terrace and the distant slopes.

FIG. 3—Mexican laborers, hired by Japanese ranchers, resetting hotcaps on cucumbers.

FIG. 4—The line between the native prickly-pear cactus and grasses in the background and the dry-farmed tomatoes in the foreground is sharp.

into the open air. Although the cost of the paper caps is comparatively slight, the thrifty Japanese ranchers often make their own plant covers by using old bread wrappers or newspaper cones (Fig. 3), erected on a tepee framework of wire or sticks, open to the south. However such devices do not survive the steady afternoon sea breeze.

Another requisite for the production of unirrigated crops is a soil sufficiently retentive of moisture to conserve the available rainfall. Soils on the Palos Verdes Hills have this characteristic to a high degree.[4] They have developed in place from shales, sandstones, and impure limestones, and the result is a dark-gray and brown calcareous adobe very difficult to work. When wet, it is heavy and sticky; when dry, it is hard and cloddy. The ranchers usually correlate the time of plowing with the first storms of the winter season. Bedrock occurs at shallow depths and in some places in outcrops, especially on the upper slopes, where denudation and erosion have been active. Fine angular rock fragments covered some fields, and it has been necessary to dispose of them in rock piles before the land could be plowed. Once cleared of rocks, however, the adobe is remarkably fertile. These fields have been farmed in vegetables for about twenty years, without the addition of any fertilizer. The present owners prefer to retain title to the land, though they may lease from season to season to the Japanese ranchers. Consequently, with a well developed tenant system, there is no incentive for the Japanese to improve the property or to prevent the depletion of soil fertility.

Historical Development

The use of the terraces for intensive agriculture is entirely a twentieth-century development, which was preceded by a period of barley growing under dry farming. Localized agriculture began as early as 1877, in the sheltered and moist canyons above the present town of San Pedro, depending on a water supply from springs above the ranch houses of the Sepulveda family, the original grantees.[5] In 1880 a small orchard of semitropical fruits grew near the ranch house, but the strong ocean winds made windbreaks desirable. On the more level coastal plain to the northeast of the Palos Verdes ranch there were at this period about 1170 acres of wheat and 325 acres of barley under cultivation. On the benches and hills there were between sixty and seventy-five thousand sheep on the open range during the spring when the grass was plentiful.

During the first half of the nineteenth century the land was a part of the typical open-range country that produced great wealth for the southern-California rancheros. The members of the Sepulveda family

[4] See J. W. Nelson and others: Soil Survey of the Los Angeles Area, California, *U. S. Dept. of Agric., Field Operations of the Bur. of Soils, 1916 (18th Rept.)*, Washington, 1921, pp. 2347–2420.

[5] Roman D. Sepulveda, MS in Bancroft collection, University of California Library. The manuscript is undated but is certainly later than 1887.

claimed to have settled on the ranch in 1827, but they did not obtain a grant of the 31,629 acres until 1846.[6] They stocked the ranch with horses and cattle, which they marketed in the mining districts of northern California from 1850 to 1860; at an earlier date the cattle supplied quantities of hides and tallow for shipment abroad. With the passing of the "cattle kingdom" after the great drought of 1862 the number of cattle in the hands of the Sepulveda family decreased, and the number of sheep increased. The land apparently was overgrazed; for the deeply slashed barrancas on the upper slopes of the hills indicate too rapid removal of the native grasses. Part of the land was occupied by prickly pear, especially on the ocean side of the hills (Fig. 4).

The fortunes of the owners declined until in 1882 a partition of the property was forced. The larger part was acquired by a single owner, and this portion remains almost intact at the present time, with the result that landholdings are large. The Japanese tenant farmers occupy the lower levels with their small vegetable gardens, but the summits of the hills are leased to Americans, who grow lima beans and barley above the 900-foot contour (Fig. 1). Fresh vegetables above this altitude do not succeed because the stronger winds damage the growing plants, but the dry-farmed lima beans are little affected by wind. An average yield of 6½ to 7 hundred-pound sacks to an acre is obtained. This type of agriculture on the tops of the Palos Verdes Hills is a unit of the lima-bean agriculture of the southern-California coastal plain. Without irrigation, the soil must be plowed from 12 to 14 inches in the fall if the winter rains are to be conserved for plant growth. Good tilth must be maintained during the winter; then, if rainfall is adequate, the beans are planted in May or earlier. In spite of careful cultivation and the best dry farming, the lima beans grown at Palos Verdes are produced under marginal conditions, and a year may pass without a profitable crop.[7] On the steeper slopes, which are unsuitable for the cultivation of lima beans, barley is planted extensively above the 900-foot level. This crop may be used for grain in years of favorable rainfall or for hay in years of drought.

The agricultural phase on the Palos Verdes Hills is not likely to be of long duration, for the land is already earmarked for urban settlement. Meanwhile we have here an interesting example of delicately balanced agriculture possible only because of careful attention to the conservation of the available rainfall. Subnormal precipitation or abnormally high temperatures on the Palos Verdes Hills almost immediately would disturb the balance between the climatic conditions and the dry-farmed truck crops.

[6] Petition of José Loreto Sepulveda and others to Pio Pico, May 29, 1846, in the files of the U. S. Land Commission, San Francisco.

[7] Production of lima beans in California has been studied by C. M. Zierer: The Lima Bean Industry of the Southern California Coastal Region, *Bull. Geogr. Soc. of Philadelphia*, Vol. 27, 1929, pp. 65–86.

MEANDERING ARROYOS OF THE DRY SOUTHWEST

John Leighly
University of California, Berkeley, California

THE recently cut arroyos of the Colorado Plateau and adjacent parts of the dry Southwest owe their prominence in scientific literature largely to the enlightening account of them by Kirk Bryan published in 1925.[1] The decade that has passed since the appearance of Bryan's paper has not seen the accumulation of new data that its author hoped to evoke. During this period, however, opinion seems to have crystallized that overgrazing, rather than one of the other agents cited by Bryan, has caused excavation of the arroyos. A recent paper by Reed W. Bailey[2] may perhaps be taken as registering both the identification of overgrazing as the agent that has released the potentially destructive powers of runoff in the Southwest and the focusing of conservationist interest on its consequences. Aside from the well founded claim that these always striking and frequently appalling evidences of misuse of land in a dry climate must have on conservationist interest, they exemplify in a considerably simplified form—as compared with the channels of permanent streams in humid climates—the action of running water in sculpturing the land surface. It is from this latter viewpoint that they are brought under scrutiny in this article.

In the summer of 1934 I was a member of a scientific party, led by Carl Sauer, that worked in the Southwest under the Soil Erosion Service of the Department of the Interior (now the Soil Conservation Service of the Department of Agriculture). From the beginning of our field work I was impressed by the sinuosity of many arroyos. As opportunity offered I mapped representative sections of them, paying particular attention to their sinuosities, many of which can without any stretching of the term be called "meanders." At the end of the field period I was able to devote a week exclusively to the completion of the series of maps already begun. The maps, reproduced in the accompanying figures, form the basis of the following discussion, which deals primarily with the meandering of the channels mapped.

The arroyos are cut in unconsolidated or poorly consolidated alluvial deposits and so change much more rapidly than do the channels of permanent streams in humid regions, which have provided the material for previous discussions of meandering in streams. The equilibrium between drainage and land surface in the Southwest has

[1] Date of Channel Trenching (Arroyo Cutting) in the Arid Southwest, *Science*, Vol. 62 (N.S.), 1925, pp. 338–344.

[2] Epicycles of Erosion in the Valleys of the Colorado Plateau Province, *Journ. of Geol.*, Vol. 43, 1935, pp. 337–355.

been disturbed only recently, and a new equilibrium is not yet attained. One finds, therefore, channels in all stages of development. I have thought that observations of these rapidly changing channels might throw light on the general problem of meandering in streams, though I have not ventured in the present article to apply any of the conclusions arrived at to the streams of humid regions. It is possible, moreover, that the series of maps reproduced does not include all the significant modalities of sinuous arroyos in the Southwest.

All the maps were made in northwestern New Mexico, within an area extending southward from the eastern part of the Navajo Indian Reservation through the Zuñi Reservation to some distance south of El Morro National Monument. The mapping was done by compass and pacing, but with care, so that as high a degree of accuracy may be claimed for it as for ordinary plane-table work. As reproduced, the maps are so oriented that the direction of flow of water in the channels is in all cases from right to left across the page.

Only one process has hitherto been described by which the arroyos are formed: headward extension. This process is to be observed very frequently and may well be the commonest one. The typical arroyo is cut in a body of alluvium much wider and deeper than the channel excavated in it, so that little control over the direction of headward extension is exercised by the consolidated rocks forming the valleys in which the masses of alluvium lie. The surface of the alluvium, moreover, is generally too even to guide the invading arroyo in a single direction to the exclusion of others. Examination of the retreating heads of the channels does not always enable one to predict with confidence the direction in which the next extension will be made. Many of the heads are bulbous, or multiple, as may be seen in the gullies tributary to the main arroyos mapped in Figures 1*a*, 3*a*, and 4; the new extension may strike out from almost any point on the periphery of the head, or from any one of several incipient heads, as local direction of surface runoff, variation in density of vegetation, or even a prairie-dog hole may determine. The course of the completed arroyo resulting from such indeterminate headward extension may be either straight or sinuous, but if sinuous its sinuosities are likely to be devoid of regularity. Figure 1*a* shows a part of an irregularly sinuous channel. The alternation of more or less straight stretches with abrupt turns and curves of differing radius can be the result only of headward extension that could not be predicted in advance and the immediate causes of which cannot be read with certainty from the completed arroyo.

Irregular headward extension may also be appealed to in order to account for the down-valley part of the channel mapped in Figure 3*a* and for the single bend in Figure 6*c*. The channel in 3*a* has certain resemblances, in size and shape of its bends, to that in *b* of the same

figure, another part of the same stream. But it can hardly be asserted that its pattern of bends is developing toward 3*b*. The sinuosities of the channel walls seem rather to be in process of elimination, and the arroyo seems to be developing directly toward the final form of such channels, an excavation wide and straight enough to carry flood discharges without suffering serious attack on its walls.

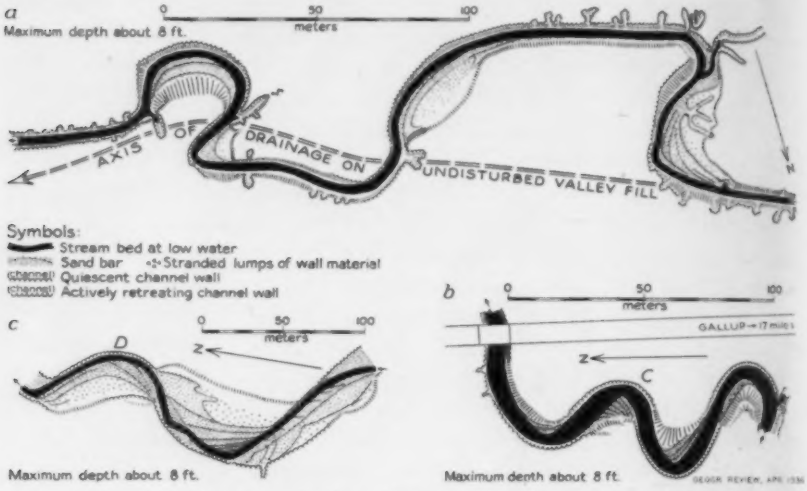


FIG. 1—Maps of sections of arroyos in northwestern New Mexico: *a*, near Fort Defiance road, Navajo Indian Reservation, about 3 miles west of its intersection with U. S. Highway 666; *b*, Mexican Springs Wash where U. S. Highway 666 crosses it; *c*, a tributary of Zuñi Creek, Zuñi Indian Reservation, 1 mile south of Zuñi Pueblo.

There is therefore little observational basis for thinking that such rhythmic meander patterns as are mapped in Figures 1*b*, 3*b*, and 4 have developed out of the irregular bends to which indeterminate headward extension gives rise. Figure 1*c* may also belong in this list, but it is farther along in the course of development toward the final form of arroyo than the other channels mapped, and the earlier states of its bends are correspondingly obscure. The history of change in the channels represented in Figures 1*b*, 3*b*, and 4 is fairly well recorded in the outlines of the channel walls and the shape and extent of the areas that have formerly been parts of the channel floors. These channels have had regular sinuosities from the time they were excavated. The origin of regular or rhythmic sinuosities in the arroyos, which will be frankly called "meanders" in the following, is the first question to be discussed.

PRIMARY MEANDERING IN THE DRAINAGE CHANNELS

At the present time it is difficult to find alluvial valleys from which one may judge the character of the drainage lines that existed before the arroyos were cut. Of the channels mapped, those in Figures 2

and 3 are changed least from their original state. They are privately owned land, 2*b* and 2*c* on a large tract lying south of the Zuñi Indian Reservation on which grazing is managed rationally and where both the natural vegetation and the alluvial valley floors are much better

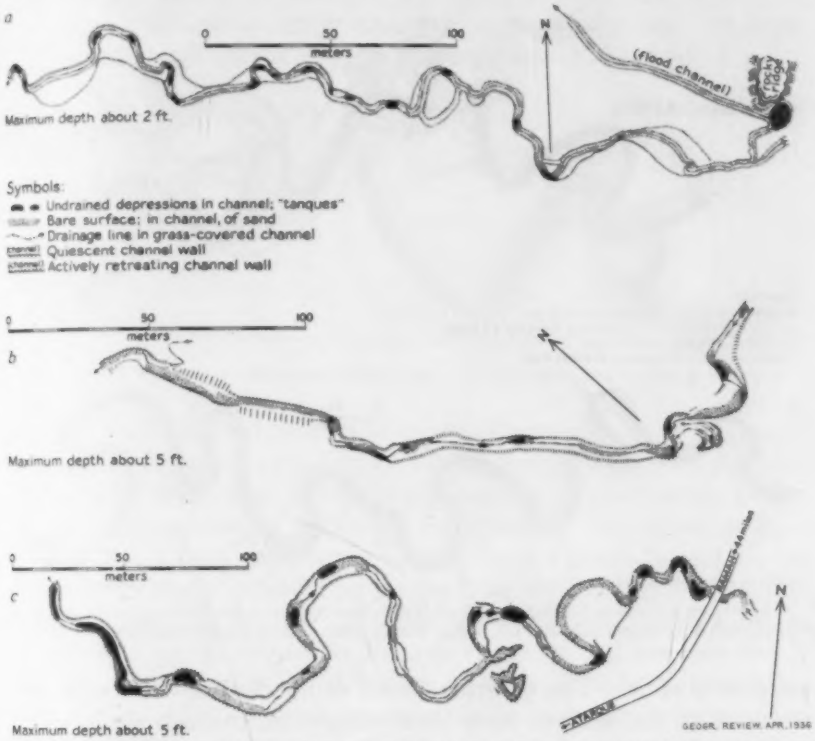


FIG. 2—Drainage channels only slightly changed from their original state: *a*, in Cebolleta Canyon, 5 miles southeast of Ramah, N. Mex.; *b* and *c*, sections of channel crossing Ramah-Atarque road, 92 miles south of Gallup, N. Mex. *b* is about ¾ mile upstream from the road crossing in *c*.

preserved than on the Indian reservations or the public range. The channels are small, incapable of carrying such discharges as flow through the arroyos that trench valleys of the same size elsewhere and that may unfortunately be expected all too soon to replace these gentle, grassy furrows.

Small meandering channels like those mapped in Figure 2 may or may not have been the usual drainage lines in the deeply alluviated valleys of the Southwest before the cutting of arroyos was begun. I cannot say whether or not the difference between the irregularly sinuous and the rhythmically meandering arroyos is an accurate reflection of a difference between the drainage channels that existed in their respective valleys before the arroyos were cut. The conclusion seems justified, however, that the difference depends on whether or not a given stretch of valley was invaded from down the valley by

a headward-extending arroyo before the local drainage channel was deepened by the process caught in an early stage in Figure 2*a*. If the primary channel was in its primitive shallow state, the new channel extending up-valley might easily trench the alluvium wholly inde-

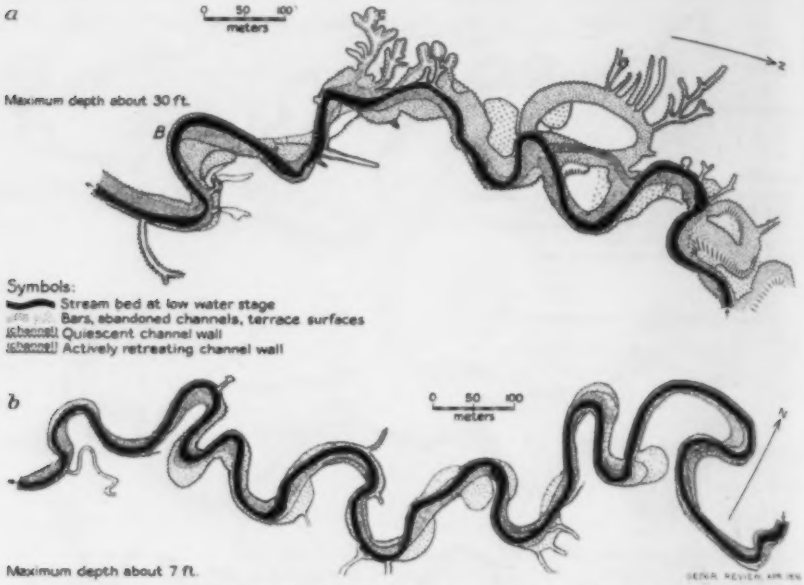


FIG. 3—Two sections of Nutria Creek, Zuñi Indian Reservation: *a*, on Nutria Canyon road about ¾ mile east of its intersection with the Gallup-Ramah road; *b*, about 2 miles upstream from *a*.

pendently of it. The question posed could doubtless be answered, even where the arroyos have been completed, through study of the courses of the arroyos, traces of earlier channels, and cross profiles of the alluvial valley floors.

The process by which the channels of Figure 2 are being changed into steep-walled arroyos is obviously very different from the irregular headward extension that produced the channel mapped in Figure 1*a*. The initial breaks in the grassy bottoms of the drainage ways have the form of discrete excavations, located at the places where in the general run of meandering streams the most intense attacks on the channel are to be expected. Where the rate of cutting is slight, as in 2*a*, the growth of grass and sedge may be sufficient to keep the localized excavations within safe limits. But if the cutting proceeds at an accelerated rate, the grass can neither heal the surfaces exposed by excavation of the channel nor maintain a saving cover of vegetation in the stretches where the grass growing in the channel is buried under the sand washed out of the excavations. The drainage line mapped in Figures 2*b* and 2*c* is in a late stage of its existence as a shallow channel. All along its length the discrete depressions—called *tanques*

by the Spanish-speaking herdsmen of the region—are present, larger and closer together in *c* than in *b*. Immediately downstream from the left end of *c* the channel has definitely become an arroyo; a certain amount of coalescence of the *tanques* along the channel is evident in the part mapped.

Figure 2 indicates clearly enough that an arroyo may inherit a plan of channel from the obscure drainage line of the original valley

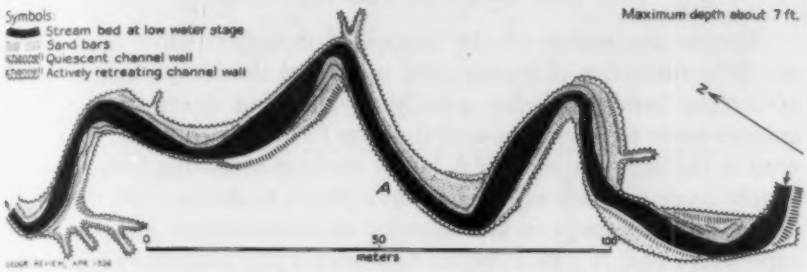


FIG. 4—Section of arroyo tributary to Nutria Creek, Nutria Canyon, Zuñi Indian Reservation.

floor. If this inherited plan is like that of Figure 2*b*, having occasional bends alternating with straight or nearly straight stretches, the final course of the arroyo will be indistinguishable from the result of irregular headward extension, illustrated in Figure 1*a*. But if the original channel had a truly meandering course, as in Figures 2*a* and 2*c*, the arroyo will have a meandering course from the beginning. Such an origin is indicated for the rhythmically meandering courses of the completed arroyos mapped in Figures 1*b*, 3*b*, 4, and possibly 1*c*. If allowance is made for the difference in scale, it is easy to imagine Figure 2*c* as taking on the character of 3*b*, if the channel is only moderately deepened and becomes adjusted to the discharge of water at its new depth.

It must frequently happen that the discharge of the stream is so increased through the acceleration of runoff that the inherited meanders cannot long survive the lateral cutting to which the walls of the new channel are exposed. The result will be an adjustment of the channel by straightening; that is, development toward a plan more in harmony with the increased discharge. This seems to be a reasonable explanation of the events recorded in the cutoff bends in the right-hand part of Figure 3*a*. Nutria Creek exhibits in this section the record of the most violent cutting, both downward and sideward, that has taken place in any of the arroyos mapped. Three cutoffs and part of a fourth are shown. Less work than was involved in cutting off these presumably inherited meanders will straighten the channel in the right-hand half of the map to such an extent that the flood discharge can escape relatively unhampered by the sinuosities of the channel.

No comparable changes in the courses of the other meandering arroyos are to be noted. Some cutting off may eventually occur in the channel mapped in Figure 3*b*, but the straightening that has already been accomplished in all the channels except 3*a* has been done by gradual attrition of the ends of the meander lobes rather than by the violent amputation of whole meanders.

The Shape of the Meanders

Earlier discussions of the shapes of meanders have been based on the examination of topographic maps and the comparison on them of stream bends differing greatly in size and orientation. Their authors seem to have supposed that the form toward which meanders tend is the arc of a circle. A better method of comparison than the simple contemplation of maps is not difficult to devise. All the qualities to be compared can be subjected to measurement and numerical expression, and it seems better to abstract the measurable qualities from the map than to depend on the simple judgment of the eye.

Figure 5*b* is an attempt to put the meanders of 3*b* into a form that permits comparison among themselves and with the meanders of other channels. Radius of curvature (on the vertical scale) is plotted against distance measured downstream (on the horizontal scale). The procedure used in obtaining the quantities plotted was as follows: On the original field sheet of Figure 3*b* a continuous line was drawn in the channel, parallel and close to the outer bank on curves, crossing over at points of inflection, and following the middle of the channel in straight stretches. This line aimed to approximate "the course of the current," in so far as that course may be considered a continuous line. With the aid of a flexible steel measuring tape, points were marked on the line at intervals of 5 millimeters. (The mapping was done on a scale of 1 : 2400, so that the interval corresponds to 12 meters in nature.) The points were numbered serially downstream. This serial numbering forms the scale on the horizontal axis of Figure 5*b*; it is indicated, at intervals of 10 points, by the small inclined numbers in 5*a*, in which the points are marked by circles. Three points at the upstream end of the section are omitted, so that Figures 5*a* and 5*b* begin with point 4. At each point the radius of curvature of the continuous line was measured.[3]

A bend or meander is here considered as beginning upstream at a point of inflection or at the end of a straight stretch and as ending

[3] Radius of curvature was measured by means of a device fashioned from a sheet of transparent celluloid. Arcs of circles were scratched into the surface of the celluloid with dividers set at radii ranging from 1 millimeter to 30 centimeters, at intervals of 1 millimeter in the short radii and increasing upward to 1 centimeter above 20 centimeters. The scratched arcs were made more easily visible by being rubbed with a colored pencil. At each point of the continuous line drawn in the channel the celluloid sheet was applied with the scratched arcs next to the map, and the arcs were tried until one was found that fitted the line at that point. The radius of the arc multiplied by the scale factor of the map gave the radius of curvature in nature.

downstream at another point of inflection or straightening. The bends of Figure 3*b* are numbered serially downstream in Figure 5; 5*a* serves to identify the bends on the map with the corresponding graphs of radius of curvature in 5*b*. The spaces under the graphs of

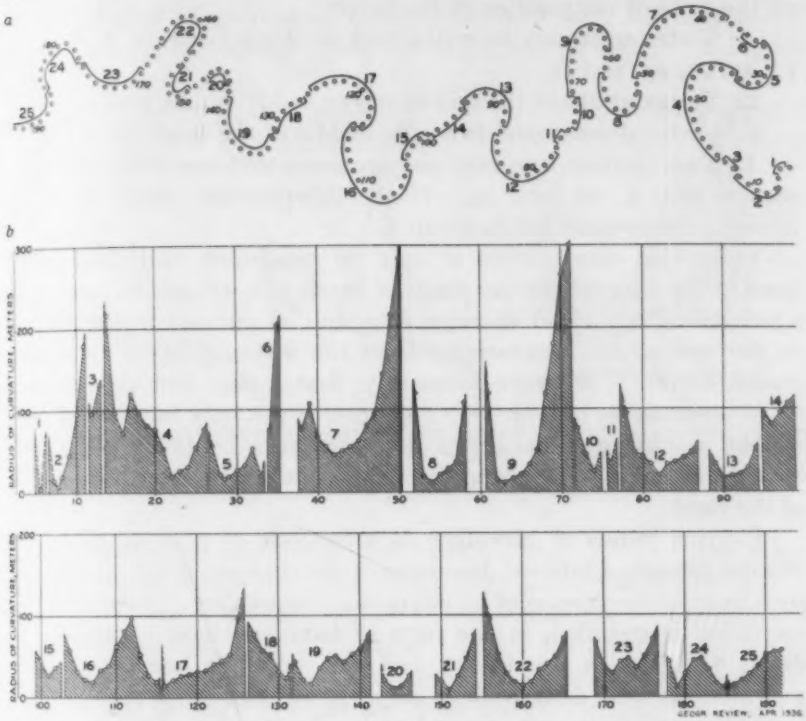


FIG. 5—*a*, index diagram to points at which radius of curvature was measured on the original of Figure 3*b*, and to the serial numbering of the meanders; *b*, graphs of radius of curvature in the meanders of the section of Nutria Creek mapped in Figure 3*b*.

radius of curvature in the individual bends, in 5*b*, are shaded separately; the blank intervals between them represent straight stretches. The blank intervals are very short at simple points of inflection and longer where the straight stretch is of measurable length. All the bends are represented in the drawing, though little significance is to be attached to the short or poorly developed ones, numbers 1, 3, 6, 10, 11, 14, 15, and 18.

Several shapes of bend are recognizable, and it is difficult at first glance to say which are typical. One conclusion, however, is safe: no bend resembles the arc of a circle, which, having a constant radius of curvature, would be represented in Figure 5*b* by a straight line parallel to the horizontal axis of the figure. Instead, the radius of curvature changes along the course of a bend, in a manner that may be defined in terms of the position of the point of minimum radius of curvature—the vertex of the bend—and the rate at which the

radius of curvature changes upstream and downstream from the vertex. The bends that give character to the course of the stream in the section mapped are those numbered 2, 4, 5, 7, 8, 9, 12, 13, 16, 17, 19, 20, 21, 22, 23, 24, and 25. They may be classified as follows, on the basis of the position of the vertex:

1. Vertex upstream from the middle of the bend: 2, 7, 8, 9, 13, 17, 19, 21, 23, and 25.

2. Vertex at about the middle of the bend: 12, 20, and 22.

3. Vertex downstream from the middle of the bend: 4.

4. Two vertices, one near the upstream and one near the downstream end: 5, 16, and 24. If the downstream vertex were not present, these would fall in group 1.

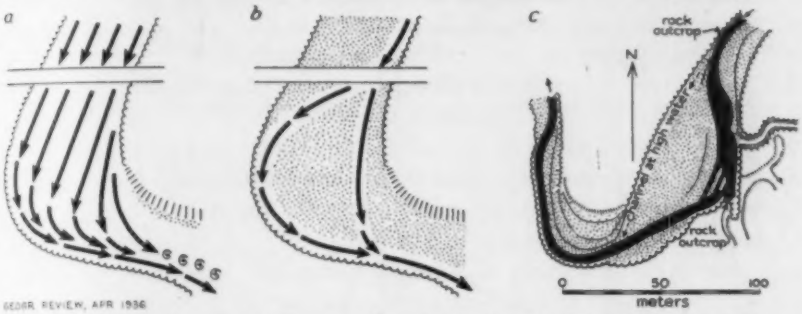
From this classification it may be concluded that the typical bend in the channel has the shape of bends 2, 9, 17, 19, 21, and 25, in which there is a rapid decrease in radius of curvature downstream to the vertex, and downstream from the vertex either a steady increase, as in 14, or, more frequently, first a slow and then a more rapid increase, as in 9 or 17. The other types may be derived from this by a shifting of the vertex downstream or by the development, as in 5, 16, and 24, of a second vertex near the downstream termination of the bend.

Plotting radius of curvature as a function of position along the channel permits a rational discussion of the changes, if any, undergone by a bend in the process of its migration down-valley. A considerable migration is recorded, in the form of bars and terrace surfaces, in bends 8, 9, 12, 13, 16, 19, 21, and 22. Of these bends that have migrated farthest down-valley, only 12, 16, and 22 depart notably from the typical pattern: 12 and 22 by the location of the vertex at about the middle of the bend and 16 by the presence of a second vertex near the downstream end. I have measured radii of curvature along only one of the abandoned meander reëntrants mapped in Figure 3*b*—the outermost one at bend 9. The plot of the radii of curvature of the edge of this reëntrant is not reproduced here; the radius at the vertex is somewhat greater than in the present channel, but the form of the bend, as defined by the location of the vertex and the rate of change in radius of curvature upstream and downstream from it, is almost identical with that of the outer bank of the present bend.

One may conclude from this examination of the bends of Figure 3*b* that what was above called the "typical" shape of meander is stable, in the sense that it may migrate down-valley without essential change. Occasionally the vertex is shifted downstream to the middle of the bend or even beyond, or a second vertex is formed near the downstream end. But these changes are not inherent in the process of down-valley migration.

One process is clearly visible that makes for the shifting down-

stream of the primary vertex and the formation of a second vertex near the downstream terminus of the bend: the tendency of the water in flood to cut across the bend, within the excavated arroyo, past the end of the meander lobe. Figures 6*a* and 6*b* illustrate the difference in the relation of current to channel between high and low water stages, in a bend resembling bend 20 of Figures 3*b* and 5. In Figure



GEOGR. REVIEW, APR. 1936

FIG. 6—Relations of current to channel: *a*, flow of water in bend of Ramah Creek at bridge on Gallup-Ramah road, Zuñi Indian Reservation, when stream was bankfull after a thunderstorm in the upper part of its drainage area; *b*, flow of water in the same bend next morning after the high water had subsided; *c*, bend in Ramah Creek near Ramah-Zuñi road just west of mouth of Horsehead Canyon, showing effect on the cut bank of stream flow at different stages.

6*a*, sketched when the stream was bankfull, most of the water takes a direct course across the bend, and a large amount of momentum is transformed into turbulent motion of water near the retreating bank in the downstream part of the bend. In 6*b*, the greater part of the low-stage flow follows a sinuous course; the cutoff flow was small at the time the sketch was made and with a slight further fall in water stage would wholly disappear, leaving the entire flow to follow the circuitous course next to the bank at the lower left. The hypothesis is perhaps justified that the "typical" form of bend represents the resultant of the sideward cutting of the stream at low and high water stages. At low stages the water follows the line of the retreating bank, so that the bank preserves its outline as it recedes. At high stages the water cuts across the bend past the end of the lobe, and the cutting it performs is concentrated in the part of the bend downstream from the vertex. The shape of a bend, from this point of view, reflects the relative influence of low and high water stages on the recession of the cut bank of the channel.

No separate effect of flow at high and low stages can be seen in the plan of the retreating bank in Figures 6*a* and 6*b*. It is visible in an exaggerated degree in Figure 6*c*, mapped a mile or so downstream from 6*a* and 6*b*. In 6*c* three or four reëntrant arcs in the steep bank at the lower edge of the map record the attack of the current at different water stages. The sharp turn at the lower left is common to all stages; but the elbow at the right is a low-water course, the path

followed by the current becoming straighter as the level of the water rises. At the low stage at which the bend was mapped, the stream (here the black represents an actual water surface) was dissecting the enveloping alluvium from about the lava outcrop at the elbow. At high stages the same corner is the scene of deposition rather than of erosion.

Discussion of the shapes of meanders in the foregoing has been

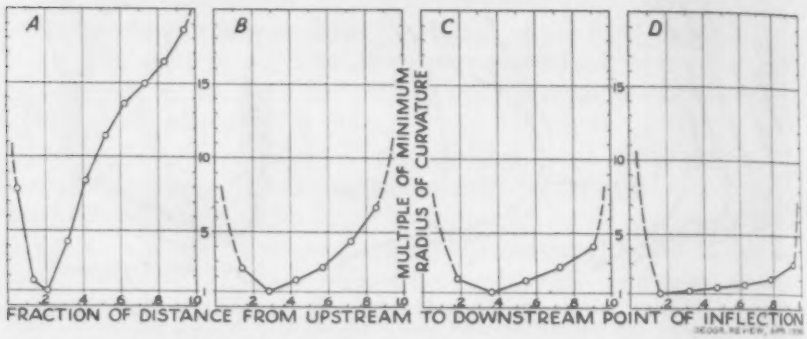


FIG. 7—Graphs of variation in radius of curvature in four bends: *A* of figure 4, *B* of figure 3*a*, *C* of figure 1*b*, and *D* of figure 1*a*.

limited to the bends of Nutria Creek mapped in Figure 3*b*, which would be acceptable in any discussion as good meanders, since they resemble the bends of the generality of meandering alluvial streams. It is worth while, however, to compare some of the bends on the other maps by means of the diagram showing change in radius of curvature along the bends. The basis for such a comparison is given in Figure 7, where radii are plotted for bends *A* of Figure 4, *B* of 3*a*, *C* of 1*b*, and *D* of 1*c*. The channel in Figure 3*a* scarcely qualifies as a meandering channel, but the retreating bank in bend *B* owes its plan solely to the action of the water flowing at its base, and only the lack of regularity in the shapes of the bends upstream and downstream prevents it from being called a meander. The curves that are being compared are those produced directly by sideward cutting of streams in homogeneous material, and from this viewpoint *B* is on an equal footing with its fellows in Figure 7. The lines whose radii of curvature were measured are the outer, steeper banks of the channels at the respective bends. Since the maps are drawn on various scales, the dimensions of the bends are eliminated in Figure 7 by plotting distance along the stream course as a fraction of the total length of the bend measured from its upstream to its downstream termination and radius of curvature at any point as the multiple of the radius at the vertex.

Different as they may appear on the maps, the bends are seen in Figure 7 to belong to the same general family of curves as the typical meanders of Figure 3*b*. *A* is a fair match for 2 and *D* for 17; and *B* and *C* might easily be fitted, except for scale, into the series that in-

cludes most of the bends analyzed in Figure 5*b*. It would seem that we can speak of a characteristic meander form in the channels mapped, which includes the angular pendulations of Figure 4 and an actively receding section of channel wall in 3*a* as well as the serpentine curves of 3*b* and the mild reëntrants of the cut banks in 1*c*.

Examination of Figure 7 raises the question whether the different shapes of bend there exhibited belong to one or more developmental series. If they do, then *A* must be at, or near, the beginning of the series, since *B*, *C*, or *D* may be derived from *A*, whereas *A* could be produced only from the same shape in the primary meander of the prearroyo channel or by sharply localized sideward cutting at the time the arroyo was excavated. The behavior of flood flows may account sufficiently for the downstream shift and rounding of the vertex that would change the shape of bend 2 (Figs. 3*b* and 5) into that of bend 8 and then of bend 13. The logical end of this course of development is the shape of bend 20 in Figures 3*b* and 5, in which curvature is limited to a short stretch at the vertex and the parts of the bend that displayed in earlier stages a rapid change in radius of curvature have become straight. This is definitely a low-water channel; flood flows cut across the bend without producing a notable effect on the cut bank.

In bends *D* and 17 the vertex seems to have remained in its normal position upstream from the middle of the bend, whereas downstream from the vertex the rate of increase in radius of curvature (measurable in Figures 5*b* and 7 by the slopes of the plotted lines) has decreased. This process, to judge from such bends as 4, 7, and 8 (Fig. 5*b*), manifests itself first at the vertex and produces a new phase of the bend that lengthens downstream from that point. To it may be ascribed the shape of the bends in which there is a distinct break in the graph of radius of curvature. The new phase has usurped most of the length of the bend in 17 and *D*, and there is no reason to believe that it may not continue its downstream extension until it includes the entire bend, except a residue that, as in the first course of development described, becomes straight. The observational data do not justify any further logical pursuit of the process, though the imagination readily invents still later phases of the same type, which would flatten the graph of radius of curvature even more and bring the bend toward the end of a second postulated course of development, toward the shape of the arc of a circle.

Appendix—Numerical Characterization of the Shapes of Bends

The plots of radii of curvature in Figures 5*b* and 7 frequently fall, through a certain distance along a bend, on a straight line. Considering the inaccuracies of mapping and measurement, the graphs representing increase in radius of curvature downstream from the vertex in *A*, Figure 7, or from the first vertex of 16, Figure 5*b*, may reasonably be considered approximations to straight lines, to say nothing of the graphs of 17 in Figure 5*b* and *D* in Figure 7. The graph is most frequently

broken, as in 8, 9, and 17 in Figure 5*b*. Where the part of the bend upstream from the vertex is long enough to show a definite shape, as in the middle part of 4, in 12, and in 18 (Fig. 5*b*), the plots of radii of curvature likewise show a strong tendency to fall on a straight line.

In such a diagram as Figure 5*b*, where radius of curvature is plotted against distance along a curve, a linear change in radius of curvature indicates that this curve is a logarithmic spiral. In polar coördinates, the equation of the logarithmic spiral is

$$\rho = \alpha^{\theta},$$

where ρ is the radius vector, θ the vectorial angle, and α a constant for a given spiral. If, for an arc of a given spiral, radius of curvature is plotted against distance along the curve (θ increasing), the slope of the straight line on which the plots of radius of curvature at two points fall is defined by the quotient of the difference between the radii of curvature divided by the distance along the curve between the two points. Or, if the two points are defined by their respective vectorial angles, θ_1 and θ_2, the radii of curvature at the points by R_{θ_1} and R_{θ_2}, and the distance between them along the curve by $S_{\theta_1}^{\theta_2}$, the slope of the graph is

$$\frac{R_{\theta_2} - R_{\theta_1}}{S_{\theta_1}^{\theta_2}},$$

which is also obviously the tangent of the angle made by the plotted line in such diagrams as Figures 5*b* and 7 with lines drawn parallel to the axis of abscissas, provided radii and distance between the points are plotted on the same scale. The essential term that defines the spiral is the constant α. This term may be found from the data plotted in Figure 5*a* by the relation

$$\frac{R_{\theta_2} - R_{\theta_1}}{S_{\theta_1}^{\theta_2}} = \log_e \alpha.$$

The following table gives mean values of $\log_e \alpha$ and α for a few parts of the meanders mapped.

MEANDER	$\log_e \alpha$	α
A, downstream from vertex	1.577	4.84
D, downstream from vertex	0.8	2.23
8, points 54–57	0.667	1.95
9, points 63–67	0.8	2.23
9, points 67–71	5.2	182
17, points 116–124	0.4	1.49

I cannot at present see any physical significance in the variations in the value of α tabulated. The slope of the graph of radius of curvature, $\log_e \alpha$, does have, however, such a significance. If radii of curvature and distance along the bend are expressed in the same units of length, the slope of the graph gives the number of units by which the radius of curvature increases (in the examples cited) in passing one unit of distance downstream. Downstream from the vertex of meander 17, that is to say, the radius of curvature increases only 40 centimeters as one goes downstream one meter; in meander *A*, Figure 4, the radius increases 1.577 meters as one goes downstream one meter; and in the downstream part of meander 9 the increase in radius of curvature is still more rapid—5.2 meters with every meter of distance downstream. The rate of increase in radius of curvature downstream from the vertices of the meanders defines concisely the shapes of meanders through the parts in which they approach, as do many of the examples here analyzed, the form of a logarithmic spiral. No attempt will be made here to find a physical basis for this tendency: there will be time for it when and if this form is found to be common among meanders.

A GEOGRAPHICAL STUDY OF NEW ENGLAND TEMPERATURES

P. E. Church

University of Washington

OF all the elements of climate, temperature plays the most significant role in New England. The precipitation is generally adequate for all crops raised within the temperature limits. Wind, sunshine, cloudiness, and humidity are minor in their effects. These statements are an outgrowth of a study in which twenty-nine isothermal maps were constructed, showing the mean monthly, mean seasonal, mean annual, highest, and lowest temperatures, mean annual range, frost dates, and length of frost-free season.[1] Seventeen of these maps are reproduced here.

Temperature Relationships

Six degrees of latitude between northernmost and southernmost New England, moderate differences of altitude, the proximity of the Atlantic Ocean, and the character of the local topography combine to produce wide differences in temperature. From north to south there is a difference of 13° in the mean annual temperatures (Fig. 1), Van Buren, Me., having the lowest mean (37.6° F.) and Pawtucket, R. I., the highest (50.9° F.). Although Pawtucket's high mean may be influenced by "city heat" to some extent, other stations along the south coast have means just below or just above 50° F. There is thus over the region as a whole a two-degree change per degree of latitude—an exceptionally steep gradient.

The effect of the ocean on New England's temperatures is admirably reflected in the pattern of the isotherms on the map of mean annual range (Fig. 1). The general trend of the isotherms is east and west, except close to the coast. Here the oceanic influence is strong enough to bend them northeastward parallel to the shore line. As a consequence, the isotherms are packed close together in northeastern Maine, and here the greatest difference (13.5°) occurs within the shortest distance (Eastport, 40.3° F.; Woodland, 30 miles inland, 53.8° F.). Between Woodland and Van Buren, 200 miles north, the range increases by less than 5°. In contrast with the abrupt change of mean annual range in eastern Maine is the gradual change along the west edge of New England, which is not influenced so much by the ocean and shows a difference of only 6.6° from north to south in a distance of about 280 miles.

[1] See also P. E. Church: The Temperatures of New England, *Monthly Weather Rev.*, Vol. 63, 1935, pp. 93–98. A complete set of the 29 maps may be consulted at the American Geographical Society and at Clark University.

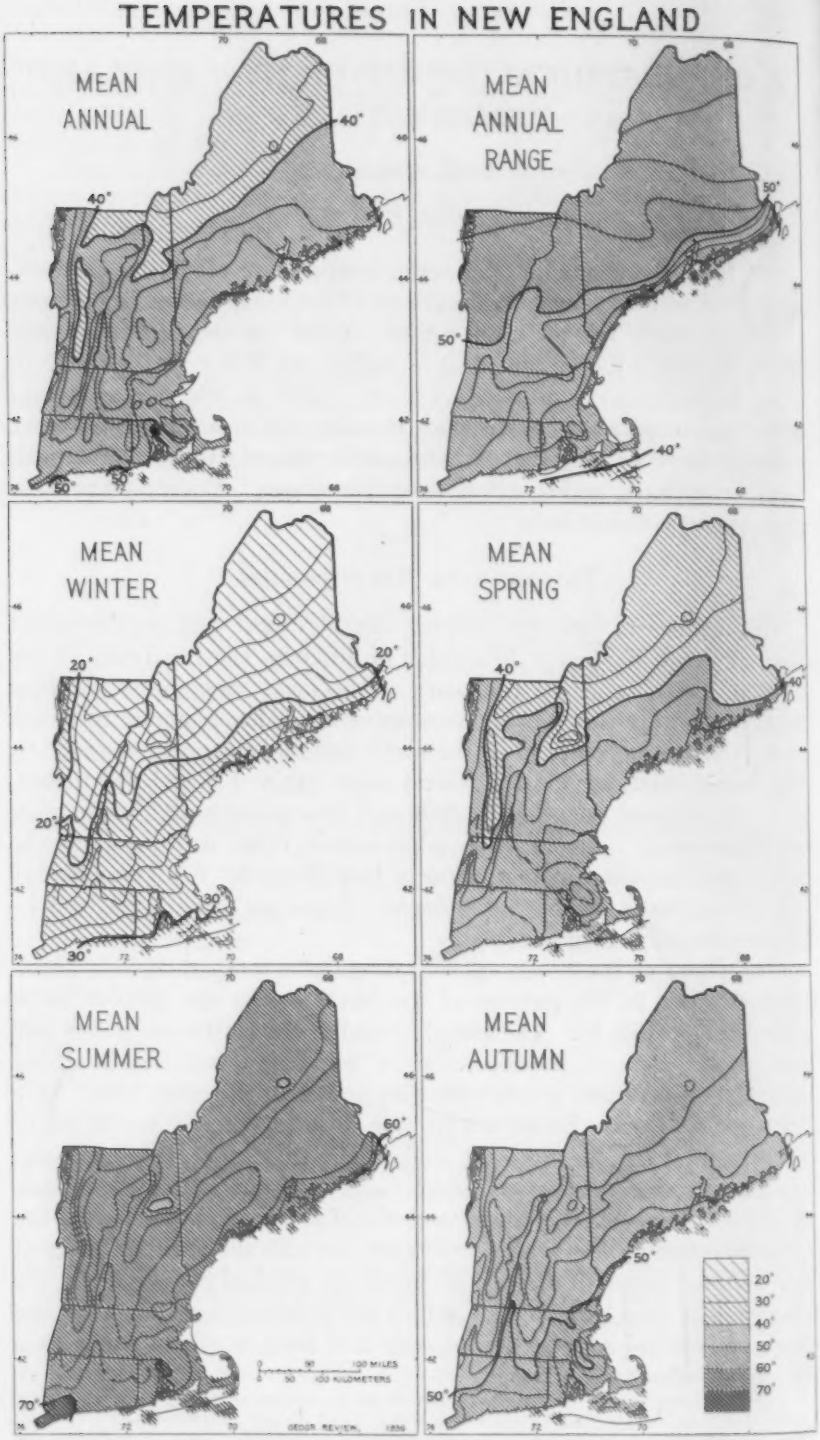


FIG. 1—Mean annual and seasonal temperatures in New England. For location of stations and length of records see the lower right-hand map of Figure 3.

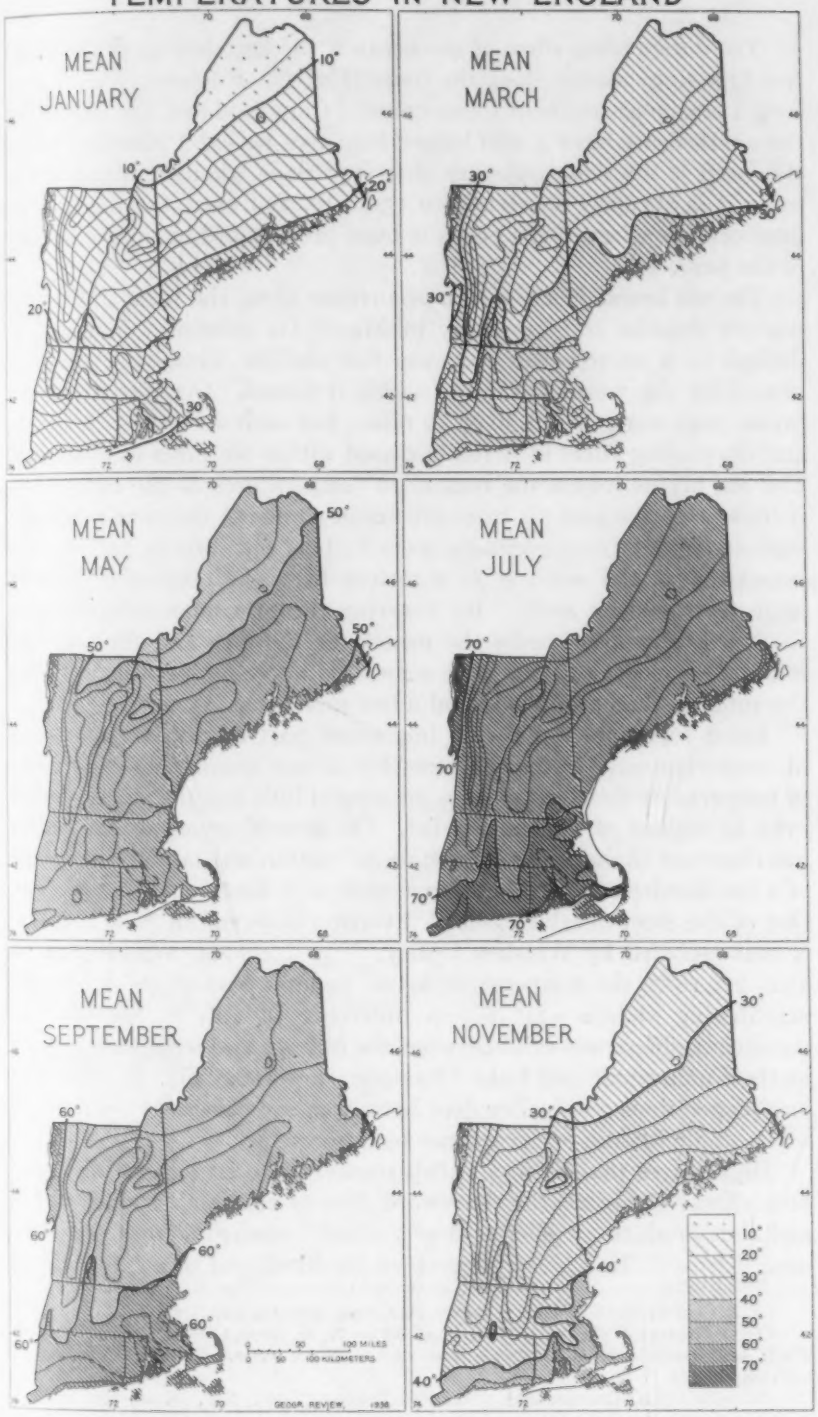


FIG. 2—Mean monthly temperatures of alternate months in New England.

The outstanding effect of the ocean is the lengthening of the frost-free (growing) season along the coast (Fig. 3). Eastport, Me., has as long a season as southern Connecticut. Cape Cod and the islands off the south coast have a still longer frost-free period. Nowhere along the coast is the season shorter than 170 days, though inland a few miles it is abruptly shortened to 150, 140, and even 130 days. The ameliorating effect of the ocean is most pronounced in the colder half of the year.

The sea breeze is a common occurrence along the coast during the warmer months and especially in May.[2] Its influence, however, is limited to a narrow belt, because this shallow wind soon becomes heated by the warm land over which it passes. Occasionally a sea breeze may work inland 30 or 40 miles, but such an event is a rarity, and the cooling effect is virtually erased within ten miles of the ocean. The sea breeze lowers the maximum temperatures of the days when it blows; for the cool air from the ocean comes at the time when the highest temperatures normally occur.[3] This accounts in part for the popularity of the seacoast as a retreat from the oppressive heat of large metropolitan areas. By lowering the maximum temperatures the sea breeze also lowers the means for the day and thus for the month. Seacoast stations have somewhat lower temperatures during the summer than stations inland a few miles (Fig. 1).

Local topography plays an important part in causing inversions of temperatures. During calm weather at any season wide differences in temperature develop between the tops of hills and the valleys below even in regions of moderate relief. On several occasions the writer has observed changes of as much as 20° within altitudinal differences of a few hundred feet in the narrow valleys of western Massachusetts. One of the most notable cases of inversion observed in New England is that reported by Winslow Upton: ". . . at Mt. Washington on Dec. 27, 1884, the temperature at the summit was + 16° F., in the neighboring valleys −24° F.,—a difference of 40°."[4] Smaller but significant differences exist between the hilltops and wide valleys such as the Connecticut and Lake Champlain lowlands (Fig. 1). Even in local depressions on a valley floor inversions are caused by some small topographic feature or even dense forest growth.

High ridges that lie in a valley transverse to its general direction may effectively block the downward flow of cold air on calm nights and thus produce a cooler area or "island" upstream from the damming barrier. This greatly increases the likelihood of a late frost in

[2] P. E. Church: The East Wind at Boston, *Bull. Amer. Meteorol. Soc.*, Vol. 12, 1931, pp. 93–94.

[3] For a discussion of sea breezes in New England see W. M. Davis, L. G. Schultz, and R. DeC. Ward: An Investigation of the Sea-Breeze, *Annals Astron. Observ. of Harvard College*, Vol. 21, Part II, 1890, pp. 215–263.

[4] Winslow Upton: Characteristics of the New England Climate, *ibid.*, pp. 265–273; reference on p. 266.

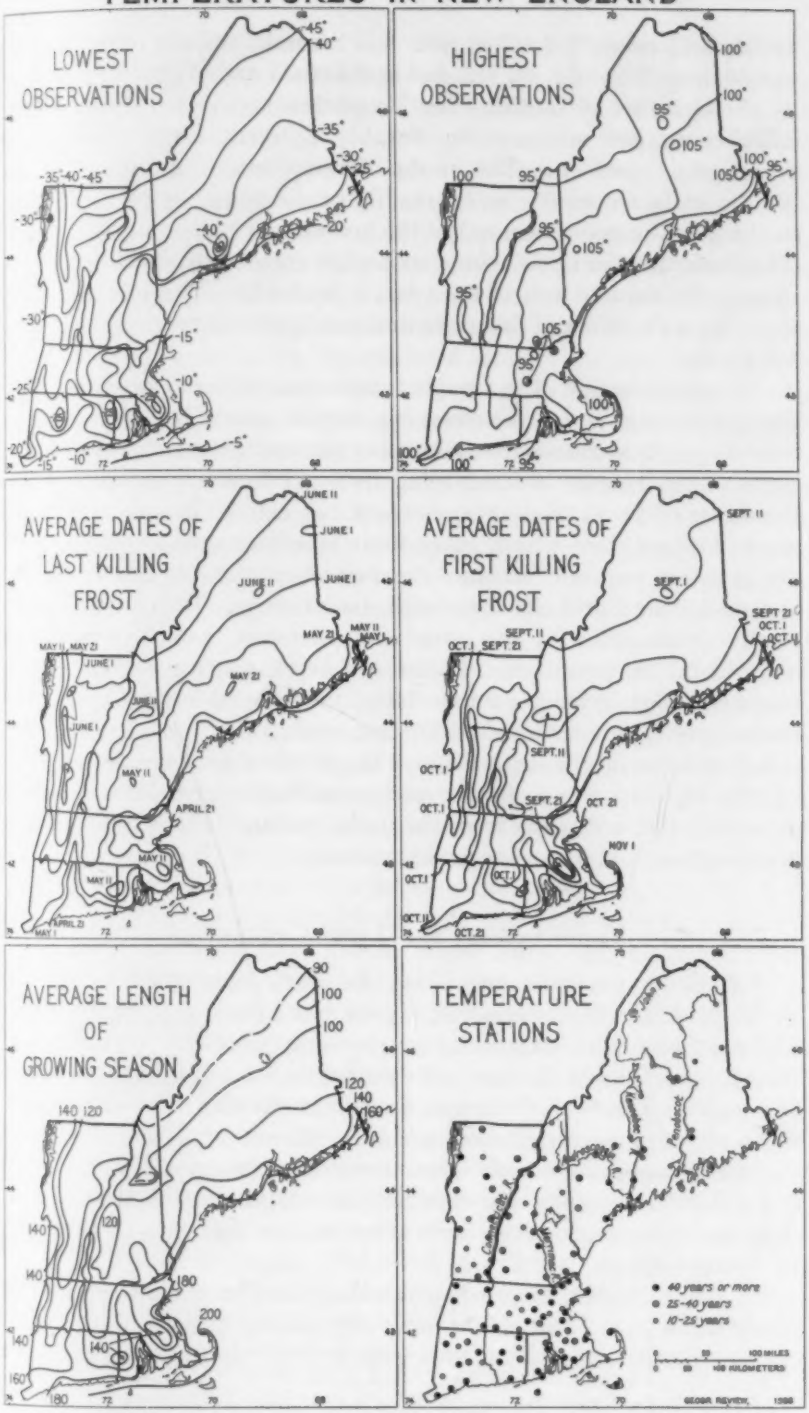


FIG. 3—Temperature extremes, frost, growing season data, and station map for New England.

spring and an early frost in fall. Such conditions are found, for example, near Concord, N. H., and at Fairfield and Winslow, Me.

A large part of southeastern Massachusetts around Taunton and Middleboro has temperatures notably different from those of the surrounding country. This is due largely to the swampy terrain. Such a surface does not warm readily in the spring or retain its heat in the fall, because a swamp has the lowest heat budget of all surfaces. The Taunton area is, therefore, somewhat cooler than its surroundings during the warmer part of the year; it is also far enough inland to be away from the effect of the ocean and is subject to late spring and early fall frosts.

The combination of the major temperature controls produces three distinct thermal areas. The first is a narrow coastal belt characterized by a longer frost-free season and lower summer temperatures than the parts of the coastal lowland lying farther inland. The ocean has a dominant effect on the temperatures of this belt. The second area is a warm lowland belt whose inner limit coincides approximately with the 500-foot contour, so that the belt thus includes nearly all the coastal lowland and the low, wide river valleys. This area is practically uninfluenced by the ocean and, therefore, has the qualities of continental temperatures. It has a shorter growing season, higher summer temperatures, greater daily and annual range, and lower mean annual temperatures than the coastal belt. The third area, which includes all the surface above the 500-foot contour and therefore all the highland areas, is also continental in its temperature characteristics but is distinct from the warm lowland belt in having lower temperatures and a shorter growing season.

Temperature and Land Utilization

Except for a narrow zone along the south coast which is included in the Middle Atlantic trucking region and a part of northern Maine and northern New Hampshire in the forest and hay region, all of New England lies in the hay and dairying region.[5] Lush, green meadows may be found in any part as a result of the cool summer temperatures and evenly distributed rainfall. However, within the three thermal belts outlined above there are local differences of agricultural crops due to the soils, the economic development, the character of the population, competition with other regions, and, to a large extent, the temperatures.

In much of New England, particularly on the uplands, a summer mean below 70° F. combines with dry, sunny periods that permit curing of hay. On the uplands climate and topography help make

[5] See map of "Agricultural Regions," Fig. 1 (p. 4) in O. E. Baker: A Graphic Summary of American Agriculture, Based Largely on the Census, *U. S. Dept. of Agric. Misc. Publ. No. 105*, 1931.

dairying the chief activity.[6] The more level parts of each farm are used for hay and forage for winter feed, and the open and gentle slopes are kept in permanent pasture. The least accessible parts are invariably left in forest, cuttings from which furnish the domestic supply of winter fuel. Various other activities are associated with dairying: in Massachusetts and Connecticut, fruit, chiefly Baldwin and McIntosh apples, plays an important part in the income of many farms. The surviving, thriving, and newly planted orchards are found on hillsides that provide good air drainage and are locally free from frost for a longer period than the hay meadows below. Fruit displaces dairying in primary importance in a few scattered areas in southern New Hampshire and eastern Massachusetts where conditions are particularly favorable. In Vermont forest products, chiefly maple sugar, form an increasingly important secondary enterprise, because the upland temperatures, especially those of the cold winter, are too low for fruit. Potatoes require cool temperatures during their growing season and hence may be raised profitably in any part of New England except at the highest altitudes. In the famous Aroostook County potato region there is a happy combination of suitable temperatures with other favoring factors.

In the greater part of the warm thermal belt, i.e. the lowlands and the low, wide river valleys, agriculture takes on a more specialized and localized aspect. Dairying is still the chief industry, but in more and larger areas than on the uplands other types of agricultural production assume primary importance. Some owe their existence to favorable temperatures. In Maine, west of the Penobscot River, the lower altitude compensates for higher latitude and produces temperatures comparable with those of the uplands of Massachusetts. Fairly large tracts in this region are suitable for fruit growing. In a few towns in southern Maine fruit is of greater importance than dairying, particularly around Sebago Lake, which is large enough to temper some of the cold winds of spring and fall. Locally on the low hills of central Maine large quantities of sweet corn are raised for canning. The cool summers make the ears ripen slowly, and thus they remain for many days in the "milk stage," which is best for canning. The corn of the Middle West remains at this stage only a few days, because of the higher day and night temperatures. The slow ripening of the corn in Maine permits leisurely gathering for the cannery. Actually the summer temperatures are too cool and the growing season is too short to ripen the corn for grain. Hence the succulent green stalks are made into silage for winter feeding of dairy stock. Peaches, which cannot stand sudden changes or very low winter temperatures, are raised in

[6] For a discussion of agriculture see I. G. Davis: Agricultural Production in New England: Present Conditions and Major Problems, *in* New England's Prospect: 1933, *Amer. Geogr. Soc. Special Publ. No. 16*, 1933, pp. 137–167.

the Connecticut Valley and eastern Massachusetts where latitude and altitude produce temperatures favorable to their growth and shelter and good air drainage make their production profitable.

Tobacco has long been grown in the wider parts of the Connecticut Valley in southern Massachusetts and northern Connecticut. Not only is the growing season at least thirty days longer in these areas than on the bordering upland, but the percentage of sunshine is higher and the diurnal range greater, so that daytime temperatures are higher. In fact, during the growing season—160 days or more on the average—climatic conditions closely approximate those of northern Illinois, except for lower nighttime temperatures in the Connecticut Valley. Here, however, the tobacco growers improve their already favorable climate, and thus increase the value of their crop, by growing the tobacco under cloth, which not only decreases the intensity of the direct daytime insolation but also conserves the heat during the night. High daytime temperatures often result in convection strong enough to produce hail, one of the worst climatic hazards in this region.

Nearly all the commercial truck gardens of New England are in the warm lowland belt. After the last killing frost in spring vegetables can make more rapid growth here than on the narrow coastal belt, even though the coastal belt has a much earlier last spring frost. Higher daytime temperatures promote quicker maturity in the warm lowland and more than compensate for the necessity of planting at a later date than is the practice along the coast.

Cranberries form the only commercially important crop of the coastal belt. This crop demands a long growing season, which must be cool throughout to prevent the growth of fungus. Optimum growing conditions are found in the United States in Barnstable County (Cape Cod) and parts of Plymouth County, Massachusetts, near the cool ocean water. Although this whole cranberry region is almost surrounded by water, it is not entirely free from occasional visits of killing frosts in fall before the crop is ready to be harvested. The danger of damage to the nearly mature crop by an early fall frost is greatly reduced by flooding the bogs. The ability of the water to maintain its heat longer than the soil thus prevents damage from freezing. In a day or two the danger of a frost is over temporarily, the bogs are quickly drained, and the crop can continue to mature normally.

Soils and Native Vegetation

Roughly speaking, there is a general coincidence between the larger soil groups[7] and the temperatures. The acidic podsols of the uplands result from the low mean annual temperature, the small evaporation, and a coniferous forest cover. Gray-brownerths, chiefly "immature

[7] New England's Prospect, map on pp. 122–123.

acidic" soils and therefore podsolic, seem to occupy the warm lowland belt and probably the narrow coastal belt. In these two regions higher temperatures and greater evaporation, in addition to a larger percentage of deciduous trees, account for the presence of these soils.

The cool summers and cold, snowy winters of the uplands permit the growth of spruce, fir, and hardy northern hardwoods such as birch, beech, and sugar maple. On lower ground in Maine, New Hampshire, and Massachusetts white pine and hemlock are predominant. Mingling with the white-pine forest are various species of oak, hickory, and ash. These cannot stand the low winter extremes of the uplands but thrive well in the temperatures of the northern part of the warm belt. The forest of this area may be described as transitional between the northern forest of the uplands and the characteristic oak-hickory-elm forest of southern New England. In southern New England the coniferous trees have almost entirely given way to the broad-leaved deciduous trees of the oak-hickory climax.

Summer Resorts and Winter Sports

The seacoast and the mountains of New England draw summer visitors and tourists from the sweltering cities of the warm lowland belt and indeed from all the states of the Union. Almost the entire length of the shore is occupied by the summer cottages of this migratory population. The greatest concentration is along the coast of Massachusetts. Cape Cod is a favored and favorite spot, its near insularity ensuring cool winds off the water, its location between the cool waters of Massachusetts Bay and the warmer waters of Nantucket Sound and Buzzards Bay making fine fishing and bathing, and its harbor-strewn south coast encouraging the amateur sailor. The coast along the Gulf of Maine is not favored as a place for swimming because the water is too cold.

The mountains, because of their altitude, are also cool retreats, but their temperatures are somewhat different from those of the seacoast. The coast has a small daily range—is relatively cool both day and night—whereas in the mountains the afternoons become pleasantly warm and the nights may be chilly. The clear, dry air permits this wide but invigorating diurnal range.

Winter sports have been developed in the past few years into a commercial venture worth noting.[8] "Snow trains" from Boston, Worcester, and other large lowland cities carry many thousands of devotees of skating, skiing, and snowshoeing to the southern part of the uplands of New Hampshire. Here the winter temperatures are low enough to ensure a continuous snow cover any time after the first

[8] R. M. Brown: The Business of Recreation, *Geogr. Rev.*, Vol. 25, 1935, pp. 467–475; reference on p. 472. See also "Existing Condition Map Showing Location Winter Sports and Carnivals," *Maine State Planning*, Vol. 1, No. 5, 1935, Map 5-B-25.

week of January until the middle of March. Most of southern New England cannot enjoy this type of sport regularly owing to temperatures high enough to prevent the formation of a deep continuous snow cover. Snow trains are, however, run from New York City into the Berkshires and the uplands of western Connecticut.

Appendix: Construction of the Maps

All the data used in the construction of the maps were taken from the records of the 125 government and coöperative stations in the six states of New England. Of this number, 24 are in Maine, 16 in New Hampshire, 19 in Vermont, 42 in Massachusetts, 18 in Connecticut, and 6 in Rhode Island. The inclusive years and length of record differ considerably, but not enough to make the study of doubtful value. There were 43 stations having a period of record of 40 years or more; 30 of these are in the three southern states. There were 80 stations having a period of 25 years or more and 122 stations having a period of 10 years or more. Only 3 had a record of less than 10 years. It was deemed necessary to adjust some of the short-period stations to the 40-year period (1889–1928). This was done for each station by forming a ratio for the same inclusive years from the observed conditions at a short-period station and at a neighboring station with a record of 40 years or more. From this ratio the probable true 40-year mean of the short-period station was computed.

The stations are fairly well distributed over the settled part of the area. The northern two-thirds of Maine and the area west of the Connecticut Valley in Massachusetts are the only large regions that show a paucity of stations. On the other hand, there is a great concentration of stations, many of which have a long period of record, within 50 miles of Boston.

Before the isotherms were drawn on the maps a careful study was made to see what clue was offered by the data of the various stations to govern the direction of the isotherms between the data points. The result showed that on the average a change of 300 to 400 feet of altitude made a difference of one degree for the monthly, seasonal, and annual maps. Therefore, it seemed most accurate to let general altitudes govern the direction of the isotherms between data points, and this practice was rigidly maintained in drawing all lines.

A 30-year period, 1900 to 1929 inclusive, was used for nearly all stations for the data for constructing the maps showing frost dates and frost-free period. This is a period ten years longer than that used in making the frost maps for the "Atlas of American Agriculture."[9] The frost dates for the short-period stations were adjusted to the long period in the same manner as the data of short-period stations for the isothermal maps.

[9] W. G. Reed: Atlas of American Agriculture, Part 2, Sect. I, Frost and the Growing Season, U. S. Dept. of Agriculture, Washington, 1918.

THE FUTURE OF THE SPARSELY POPULATED RURAL TOWNS OF CONNECTICUT*

J. L. Hypes
Connecticut State College

THE purpose of this article is to describe very briefly some of the more recent social changes taking place in the sparsely populated rural towns of Connecticut and the implication of these changes.[1] The number of inhabitants, vocations, national origins, the combination of places of residence and of work (or commuting), and trends toward urbanization are selected for consideration.

Shift in Numbers and Vocations

Although population depletion in many rural towns and concomitant increases in urban and suburban areas have gone on for many years, it is probable that the movement was not widely recognized until the report of the American Country Life Commission, published in book form in 1911.

Recent trends in the cityward drift of the rural population in Connecticut are set forth in the study entitled "Population Mobility in Rural Connecticut."[2] It was found, for example, that nearly half the towns of the state—on the whole, those that are the most sparsely settled—either have declined in numbers or have a practically stationary population (Fig. 1). The towns that either are decreasing in population or had a negligible increase for the decade ending 1930 are distributed chiefly along the eastern and the western highlands in a north and south pattern.

The obverse side of this picture is shown on Figure 2. Here are 14 towns whose populations have increased 50 per cent or more during this decade. These are principally on the outskirts of the large cities and along the shore near New York.

Closely connected with population mobility in rural Connecticut is a shift in occupation. In earlier days farming had a wide vocational interest for the inhabitants of New England, and even though much of this farming was part-time, a relatively large percentage of the population could be termed farmers. Today the rural-farm population is practically nil in the three southern states of New England, though it still constitutes a rather important part of the population in the three northern states. In Connecticut in 1930 only 5 per cent of the population could be classified as *rural-farm* population. Even so, we know from the rather generous definition of farming given by the United States Bureau of the Census that probably most of these farmers can be so listed only as a matter of courtesy. Their chief sources of income are nonagricultural, and much of their farming is part-time and recreational. A recent survey of part-time farming in Connecticut, based on a rather liberal definition of such farming, indicates a significant increase in the number of people

*This article deals in the main with findings of recent investigations of the Storrs Agricultural Experiment Station. For more detailed and quantitative accounts of the movements considered see the following bulletins of the Storrs Agricultural Experiment Station: *Bull. 161*, J. L. Hypes and J. F. Markey: The Genesis to Farming Occupations in Connecticut, 1929; *Bull. 182*, J. L. Hypes, V. A. Rapport, and E. M. Kennedy: Connecticut Rural Youth and Farming Occupations, 1932; *Bull. 194*, N. L. Whetten and V. A. Rapport: The Recreational Uses of Land in Connecticut, 1934; *Bull. 196*, J. L. Hypes: Population Mobility in Rural Connecticut, 1934; *Bull. 201*, I. G. Davis and L. A. Salter, Jr.: Part-Time Farming in Connecticut: A Preliminary Survey, 1935.

[1] The term *town*, as used in this article and as customary in New England, does not refer to *village* or *city* but to *township*, *magisterial district*, or other similar units of local government in other states.

[2] *Storrs Agric. Exper. Sta. Bull. 196*, 1934. Certain phases of this study were analyzed from data taken from the 1930 census of the United States; thus it must be recognized that these data are not so recent as one might wish. Furthermore, it must be borne in mind that because of certain local situations more or less peculiar to New England the census distinctions between *rural* and *urban* do not always have a very clear-cut or valid application here.

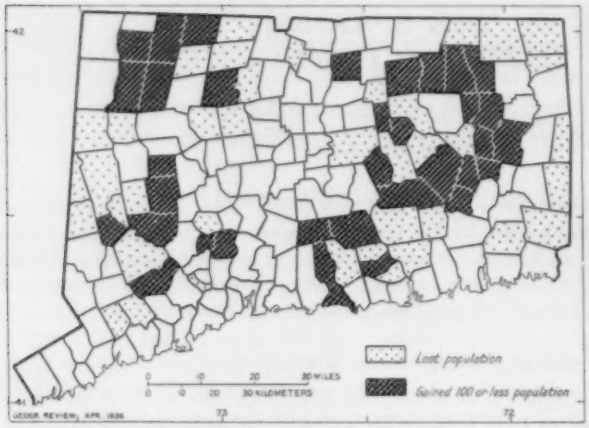


FIG. 1—Connecticut towns that have either lost population or gained not more than 100 during the decade ending 1930.

going into farming in the state in recent years. Yet, even if these findings are accepted at their face value, the percentage of the population that is engaged in farming is very small.[3]

In 1880 the acreage of improved farm land was 1,064,525 acres; in 1930 it had dropped to 670,973 acres. Concomitantly in 1930 the *farm* population was only one-fifth as large as the *rural-nonfarm* population. The rural population of Connecticut is in no sense of the word a strictly agricultural population.

A complementary picture is presented in Figure 4, showing the recreational use of land in the state. Superimposed on Figure 1 it shows that, to a great extent, the land utilized for recreational purposes lies in the areas where population densities are small and decreasing. As a great deal of the land in the two highland regions of the state is too stony, steep, and rough for profitable extractive farming, it would seem that this shift to recreational use is both logical and economically sound.

Shift in National Origins

A marked change in the national origins of the population of Connecticut has also taken place.[4] In 1930 only 33.5 per cent of the entire population of the state were of native-born white parentage; of the rural-farm population 42.1 per cent were of native-born white parentage. In many rural schools of the state the entire student body consists of children whose parents were born abroad.

FIG. 2—Percentage of gain and loss of population among Connecticut towns during the decade ending 1930.

The foreign migrants to Connecticut rural towns are chiefly of urban origin. Most of them have lived for a while in our large cities and have en-

[3] See *Storrs Agric. Exper. Sta. Bull. 201.*

[4] Cf. J. L. Hypes: Recent Immigrant Stocks in New England Agriculture, *in* New England's Prospect: 1933, *Amer. Geogr. Soc. Special Publ. No. 16*, 1933, pp. 189–205.

gaged in urban occupations before "trickling back" upon the land as rural settlers. This not only tends to introduce new folkways and new social cultures into the rural towns but facilitates their urbanization as well.

FIG. 3—Population densities of Connecticut towns in 1930.

These movements themselves have been undergoing change. In recent years, for example, a lessening has been reported in the trek of the immigrant population to the rural towns. Our recent immigration laws have reduced greatly the inflow of migrants into this country, and this in turn ultimately has reduced the settlement of immigrant urban dwellers upon the land. This fact and the disinclination of the former Yankee farmers to begin anew a hand type of agriculture in the rural areas abandoned by them are probably the main proximate reasons for population depletion in a large number of these rural towns.

COMMUTING AND RURAL URBANIZATION

Certain countervailing movements, however, seem to be facilitating social adjustments. The most important of these is commuting, whereby rural residence and urban occupation are being combined on a rather large scale and, vice versa, urban residence and rural employment are practiced to some extent. In one of our studies a third of the rural families were found to be commuters' families, even when the definition of a commuter was so rigorously drawn as to eliminate many intermediate types of rural commuters and all the urban dwellers who commute to rural employment.[5] It is of course current improvements in the means of transportation and communication that have made this movement possible.

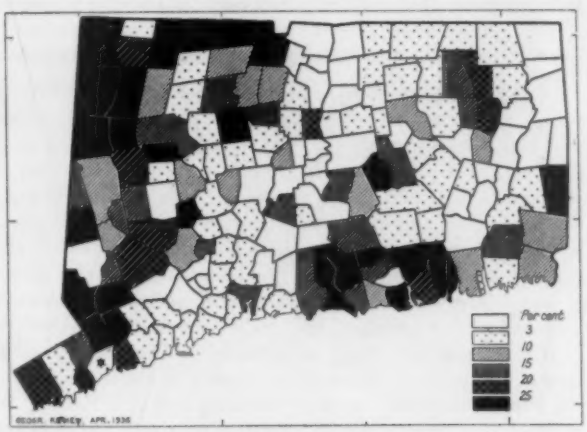


FIG. 4—Percentage of total land area devoted to recreational uses in Connecticut towns. *Information incomplete for the town of Norwalk.

The relatively small proportion of the rural population that follow farming pursuits on a commercial scale, the relatively large proportion of the farmers who

[5] See *Storrs Agric. Exper. Sta. Bull. 196*, pp. 36–37.

are urban,[6] the growth in the number of rural dwellers who commute to urban employment, and the pronounced growth in the recreational use of land—these all bear witness to an advanced condition of urbanization of the rural population of Connecticut and the other two southern states of New England. Other studies have shown that rural populations in New England maintain standards of living similar to those of city groups with equivalent incomes: rural people possess automobiles and radios, read daily papers, and send their children to high school much as city people do; and, like city people, rural people here are cosmopolitan in national origins, are mobile as to residence, and otherwise behave like similar urban groups.

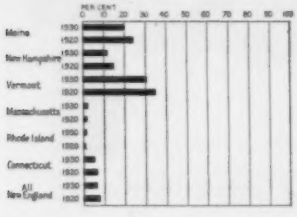


FIG. 5

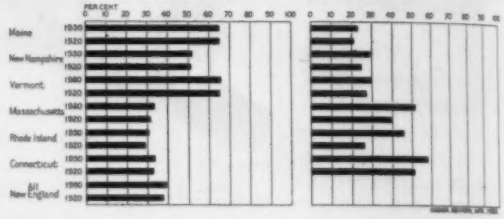


FIG. 6

FIG. 5—Percentage of the total population of New England classed as rural-farm population in 1930 and 1920.

FIG. 6—The left-hand graph shows percentage of total population of New England of native-born white parentage in 1930 and 1920.

The right-hand graph shows percentage of rural-farm population of New England in 1930 and 1920 white foreign-born, or of white foreign-born or mixed parentage.

In fact, a large percentage of the rural dwellers of Connecticut have previously lived in the city. In one rural Connecticut town it was found that 80 per cent of the families had at one time or another lived in the city; and, as previously stated, it is certain that practically all the immigrant rural dwellers, both farm and nonfarm, have come from previous city homes and city employment. Thus by whatever index we examine this question we must conclude that southern rural New England, taken as a whole, culturally and socially is highly urbanized—or at least is in many important respects similar to equivalent social and economic groups in the city.

COMMERCIALIZATION IN FARMING

Certain aspects of this rural urbanization need further comment. As with most urban industries and professions, much of the farming has become highly specialized and highly commercialized. For example, most of the shade-grown tobacco of the Connecticut River valley is grown by corporations, and much of the field-grown tobacco is produced under the supervision of the tobacco buyers. Moreover, on the proceeds of this one crop, supplemented perhaps by the returns from a few other minor farm enterprises or a little outside employment, the tobacco farmers must support their families. To a pronounced degree the commercial business aspects of farm life, in terms of specialization in production, volume of business, profits, etc., overshadow the "mode of life" values heretofore inherent in the farm.

This commercialization of farming has a special significance to vocational education in agriculture. Aside from mastery of the few simple operative processes that the average farm boy already possesses and that the city boy can quickly learn on the job, the hired hands and farm owners who are engaged in tobacco production under these arrangements do not have to be experts. This is true because the managerial functions, which are crucial in this kind of commercialized farming, are assumed largely by the buyers or by the foremen in the employ of the corporations.

[6] *Ibid.*, p. 11.

Consequently, aside from the special research and extension education of the agricultural experiment stations and a limited amount of extension education through the Farm Bureau, there is but little real need among "dirt farmers" for extended vocational education of the manual sort in tobacco production.

What is said of tobacco production cannot, perhaps, be said with equal certainty of dairying and other specialized types of New England farming, which, as yet, are developed largely along lines of individual entrepreneurship. Even in dairying, however, the weightier problems of marketing, herd improvement, veterinary service, etc. are being more and more dealt with by specialists furnished by the Farm Bureau, the Agricultural College, and the coöperative association or specialists in the farmers' own private employ, who, in a measure, perform technical and supervisory functions similar to those assumed by the foremen in the corporative type of tobacco farming previously mentioned. This fact brings into question certain methods formerly employed by many Smith-Hughes high school departments of agriculture, in which unduly great stress was placed on the simple manual operative phases of farm work. It seems to us that the Danish vocational schools in agriculture have met this problem in a constructive way by offering courses in the sciences basic to agriculture, along with technical courses in agriculture, to mature young men who by previous apprenticeship experience have not only selected their vocations but mastered the operative phases of them. The functions of the school then are chiefly to explain, in terms of basic science, the whys and wherefores of the operations that the students have already mastered and to interpret the economic, social, national, and international significances of their vocations—the phases the students can gain better in school than by apprenticeship. However, the writer freely acknowledges that many social and economic forces have combined to change the nature of the apprenticeship system in vogue in this country in earlier days and that, through research, the value of apprenticeship in its current modified forms needs to be determined in specific types of conditions and vocations.

Educational Advantages and Social Organization

Another aspect of this urban-rural relationship and its significance to education is the rich educational opportunity that it provides public schools. Through school consolidation and the transportation of the pupils in busses many rural children are afforded the privilege of attending centralized graded and high schools in the large villages and cities. This urban contact gives them the advantages of larger libraries, museums, theaters, stores, shops, etc. not usually found in the rural areas. On the other hand, rural residence gives them the opportunity of becoming members of the boys' and girls' "4-H" club organization. In many cases this organization renders fine educational and recreational functions through the promotion of garden clubs, poultry clubs, calf clubs, health clubs, handicraft clubs, homemaking clubs, fairs, roundups, etc. Correlatively the urban-rural combination of environments provides exceptional facilities for the city child to become acquainted with rural occupations.

Similarly educational advantage could be taken of the heterogeneity of the population in both national origins and the associated culture traits.

The population has become so sparse in a number of the rural towns of Connecticut as to make it impracticable if not impossible for these towns to have high schools of their own or perhaps even their own consolidated elementary schools; hence the proposal to establish regional high schools in certain rural areas. Furthermore, because the rural towns do not have wealth enough to support their schools according to minimum desirable standards, the state has had to provide a huge sum for equalizing educational advantages throughout the state.

The rural church, too, has special problems of organization that are produced

in part by the social changes noted above. The problem is frequently made still more difficult by a divisive force that breaks up the Protestant element of the population into different competitive congregations and that sets off rather distinctly the Protestant, the Catholic, and the Jewish faiths intermingled in the sparse population that makes up many of our rural towns.

These social changes also have political significances that cannot be overlooked. The infiltration of large numbers of immigrants into the population of Connecticut, both urban and rural, places at the foundation of the state's voting strength a large number of citizens who have lived in the past under forms of government under which they have not enjoyed much participation as independent, and free voters. This essentially places a heavy burden upon current efforts of Americanization and civic education. But perhaps the most striking political result of current social movements is the uneven representation of the various population units in the General Assembly. To illustrate with an extreme example of the rotten-borough system: in 1930 the population of the rural town of Union was 196; in the same year the population of the city of Hartford was 164,072.[7] In the General Assembly each has two members in the House of Representatives. In other words, in this branch of the legislature a citizen of Union had 837 times the voting power that a citizen of the city of Hartford had.

A Change in Social Control

Another aspect of these changes and a further index of the urbanization of rural areas are found in the growth of impersonality in the rural neighborhoods in southern New England. The population that moves its residence frequently and is heterogeneous in religion, national origins, degree of literacy, and social customs does not care very much "what the neighbors will say."

This change in social control also makes difficult the organization of the people of a locality for group participation. Thus in one of our Connecticut studies on social participation it was found that out of 70 native-American households studied 66, or 94 per cent, were represented on the legal list of voters, whereas of the 74 immigrant households studied only 17, or 23 per cent, were represented. In the same study it was also found that whereas the average native-American household belonged to 5.2 voluntary primary group organizations, outside of family groupings in the town the immigrant Poles belonged to only two such organizations, the immigrant Germans to one, and the immigrant Jews to 2.4. It was also found that among the different nationality groups of citizens there was very little social intercourse except that incidental to business activities. Moreover, this town was found to provide within its own borders only 30 per cent of an itemized list of social, professional, and economic services enjoyed by its citizens. Even though this rural town is in east-central Connecticut, it was found that New York City, Boston, Hartford, and a number of other cities were the focuses of many interests of its citizens. Evidently the wide ownership of automobiles and a fine system of improved roads facilitated the satisfaction of these interests. Such trends explain, at least in part, the passing of many traditional rural folkways and institutions; and they throw light on many current difficulties in rural social organization.

There is, however, one contrary movement that may modify certain of the problems mentioned above, and that is the growth of a class of commuters. It includes many intelligent, public-spirited citizens from whom we may expect the rise of a more intelligent rural leadership than we probably have had in the recent past, and it may be that many of the problems of these towns will ultimately be happily solved by their own people.

[7] *State of Connecticut Register and Manual, 1931*, pp. 748–751.

THE CHANGING SEA LEVEL: A REVIEW AND DISCUSSION*

Douglas Johnson
Columbia University

THE Institute of British Geographers has done well to issue in booklet form four lectures delivered at the University of London by Henri Baulig of the University of Strasbourg. For Baulig, keen and analytical investigator in the field of geomorphology, has devoted much study to supposed evidences of ancient marine levels found in France and elsewhere.

The first lecture, forming Chapter I of the present publication, is "A Critical Retrospect" of the long-debated problem of what causes changes in the relative levels of land and sea. The author properly recognizes that such changes may result from movements of the land alone, from movements of the sea alone, or from movements of both land and sea occurring successively or simultaneously. In his opinion the "eustatic interpretation," namely that such relative changes are due to uniform rise or fall of the ocean surface throughout the world, has been unduly neglected by geologists and geographers. *Glacio-eustatism*, or changes in sea level due to accumulation and melting of successive icecaps, and *deformational* or *diastrophic* eustatism, changes in sea level due to variations in the capacity of ocean basins, are discussed, and a serviceable review of past work in these fields is presented. Throughout the chapter Baulig shows a far keener appreciation of the great difficulties involved in correlating coastal and river terraces than is shown by most writers, European and American, who have attempted such correlations.

In the second chapter the author discusses what he calls "A New Line of Research: The [Study of] High Levels of Erosion." Those familiar with the long use of high-level erosion surfaces, "valley-in-valley" forms, and other inland features as evidences of changes in the relative level of land and sea may question the appropriateness of the adjective "new"; but they will readily grant that Baulig has gone further than most investigators in explaining such features as the result of eustatic shifts of sea level. It does not seem, however, that Baulig sufficiently recognizes the serious difficulties that beset the interpretation of inland erosion forms.

Noncyclic Forms

Streams developing on a newly uplifted land mass normally have falls and rapids, either as the result of inequalities in the initial slopes of the land or as the result of trenching alternating belts of resistant and nonresistant rocks. The time required for waterfalls to work headward through very resistant rock barriers may be sufficient for valleys above the barriers to acquire submature or even mature forms. When the barriers are finally trenched, youthful gorges will be incised in valleys of more mature aspect. The continued up-valley propagation of a fall or break in slope requires still further time; and in so long a period the upper tributaries of a stream may develop moderately open valleys, even in resistant rocks. When the wave of erosion finally reaches that remote area, young gorges are cut in older valley forms, in rocks of uniform and possibly great resistance, yet without cyclic significance.

Such valley-in-valley forms of noncyclic significance are expectable as frequently repeated features of a stream in its first or any later cycle of development. They may be observed far upstream from the barriers that caused their existence; but the structural control, although remote and hence often unobserved, is none the less

*Henri Baulig: The Changing Sea Level: Four Lectures Given at the University of London in November, 1933, *Inst. of British Geographers Publ. No. 3*, George Philip & Son, Ltd., London, 1935.

real. A single barrier far down a trunk stream may give rise to knickpoints or *ruptures de pente* and valley-in-valley forms, found in all headwater tributaries and over vast areas of homogeneous rocks. They may be correlated within one drainage basin, or throughout several drainage basins if the barrier extends so far, in precisely the same manner as the similar forms due to sea-level changes. Local upfaulting across one or more trunk streams may give rise to the same correlatable forms not directly associated with apparent structural control. So may stream capture. That Baulig finds breaks of slope "in the very midst of massive crystalline rocks" and that various tributaries show correlatable breaks of slope are not sufficient to justify his conclusion that they must be the result of sea-level changes.

Cyclic Forms Disintegrated, Compounded, or Obliterated

Now let us change the picture and imagine that a series of cyclic waves of erosion, due to successive drops of sea level or to successive uplifts of the land, are propagated headward along various river systems. What will be the result? If the streams everywhere traverse rocks of uniform resistance, and if no local earth movements affect any of the streams, we may expect uniform headward propagation of the breaks in slope to give a series easily correlatable throughout the several drainage systems. But where do we find large areas with the required uniformity of rock resistance? Vertical alternations of resistant and nonresistant strata, horizontal alternations of varied rock types, greatly jointed and little-jointed areas of a single rock type, crushed zones along faults, and other factors assure abundant contrasts in resistance to erosion in most drainage basins. The falls or breaks in slope resulting from relative changes of sea level are propagated upstream until they strike some resistant barrier. There they are checked for a relatively long period, as Baulig fully recognizes. "No wonder that we, as ephemeral observers, are apt to find them more commonly in the latter position [on hard outcrops] than in the former [in weak rocks]."

The consequences of this fact are more far-reaching than Baulig seems to realize. A second and a third cyclic wave of erosion "passing rapidly across weak rocks" may in turn be checked at the hard rock barrier. It is, of course, theoretically conceivable that each earlier wave of erosion may have cut somewhat farther back into the resistant rock than the next succeeding wave. But unless the weak rock overlaps the resistant rock with a gently sloping contact, and unless the resistant rock is itself relatively free from irregularly distributed structural or other weaknesses, the several cyclic waves are, according to the nature of the barrier, apt to be either telescoped into a single break in slope, such as a waterfall, or disintegrated into a succession of falls or rapids the number of which depends on the irregularities of resistance within the barrier and not on the number of cyclic waves reaching the obstruction. Thus three cyclic waves arriving at the barrier may ultimately emerge from it and be propagated farther upstream as a single break in slope, or as half-a-dozen breaks in slope, none of them directly of cyclic significance. This thing must happen not once but repeatedly in any ordinary drainage system.

As hard rock barriers, local earth movements, river capture, and other causes may, under favorable circumstances, produce throughout one or more drainage systems noncyclic breaks in slope that are susceptible of correlation in greater or less degree, and as such barriers tend to transform cyclic breaks of slope into a different number of noncyclic breaks that may or may not correlate according to the nature and extent of the resistant barriers, it must be evident that the interpretation of such breaks in slope (knickpoints, *ruptures de pente*) presents difficulties far more serious than has generally been recognized.

Thus far it has been assumed, as proponents of the cyclic theory of knickpoints commonly assume, that a break in slope is propagated indefinitely upstream. Al-

though it seems to be true that a fall or rapid normally retreats upstream hundreds of feet while the stream cuts vertically downward one foot, we must recognize the possibility that vertical downcutting above breaks in slope may in time grade streams to even profiles and thereby eliminate many waves of erosion, whether cyclic or non-cyclic in origin. In the opinion of so excellent an authority as William Morris Davis,[1] "after nicks of any kind are fully produced they are, as a rule, slowly worn upstream and obliterated." Whatever the measure of importance of this factor, it tends to complicate or partially destroy that perfection of the record on which any safe conclusion in favor of sea-level changes must rest.

Theories and Facts

When erosion forms are correlated, there are certain prerequisites indispensable to sound conclusions. First, the things correlated must be truly comparable. In the opinion of the reviewer, Baulig and all others who have attempted the correlation of knickpoints, terraces, and valley-in-valley forms have failed to recognize the importance of this fact and have oversimplified their task by limitations and assumptions of questionable validity.[2] In the second place, the data employed in correlation must be clear and precise. Obviously, if one may correlate vague and therefore doubtful knickpoints, terraces, and valley-in-valley forms in certain localities with clearly defined forms in others because such correlations help to give a consistent result, one may prove any theory one wishes. Finally, if conclusions are to carry conviction, there must be a high degree of perfection in agreement of data compared. The reviewer is impressed by the extent to which the literature of knickpoint, terrace, and valley-in-valley correlations abounds in such expressions as "it seems probable that . . . ," "this apparent discrepancy can be explained . . . ," and the like, expressions strongly indicative of lack of clarity and precision in the data dealt with.

Baulig's third chapter, entitled "Interpretations," carries the reader into highly theoretical discussions of what should and what should not happen during isostatic and related movements of the earth's crust. The arguments so ably presented by Baulig need not be reviewed here; for, as long as the precise nature and cause of isostatic readjustments of land masses are matters of controversy and investigation, one must hesitate to accept even the ablest personal judgment regarding what should happen under assumed conditions as a basis for determining whether movements of sea or land actually give rise to supposed cyclic erosion forms.

The last chapter, "In Search of More Facts," reviews the author's own researches in this field of inquiry, describes some of the methods he employed, and summarizes his conclusions. Some of these have been discussed in an earlier number of the *Geographical Review*.[3] If the determination of erosion levels presents difficulties, the proper correlation and interpretation of such levels over broad areas are doubly difficult. Baulig ably sets forth some of these difficulties, with illustrations taken from his own far-reaching studies. With him as guide the student of sea-level changes as recorded in coastal features and inland forms will learn much to make his own work more critical and accurate. No one working in this field can afford to neglect the admirable discussions condensed in this little booklet of less than fifty pages by a master of geomorphic research.

---

[1] W. M. Davis: Piedmont Benchlands and Primärrümpfe, *Bull. Geol. Soc. of America*, Vol. 43, 1932, pp. 399–440; reference on p. 416.

[2] For a recent illustration of this procedure see S. W. Wooldridge and J. F. Kirkaldy: River Profiles and Denudation-Chronology in Southern England, *Geol. Mag.*, Vol. 73, 1936, pp. 1–16. Three pages at the beginning of this paper are devoted to setting forth "the body of ideas which form the basis and background of the work." These are, in effect, limiting assertions and assumptions, with very few of which the reviewer would find it possible to agree.

[3] Douglas Johnson: The Central Plateau of France: A Review, *Geogr. Rev.*, Vol. 19, 1929, pp. 662–667.

A STUDY OF HISTORY: A REVIEW*

A. Grenfell Price

GEOGRAPHERS will greet Professor Toynbee's search for the vital force in civilization with profound interest. The three volumes now published examine the evolution and growth of human societies over a great sweep of time and space. They form part of an immense plan. They have been hailed with almost reverent admiration by British historians and sociologists. Any worker in a comparatively limited field must approach with diffidence a thesis of such range, scholarship, and literary charm. In speaking of H. G. Wells's "Outline of History" Toynbee himself warns those who are prone to discover errors where immense generalizations cross their tiny allotments. Yet not only must this study of civilization convince the few scholars who can comprehend it as a unity, but its premises and conclusions must also withstand the assaults of an army of specialists.

To the geographer almost every section in these volumes is of interest. Although Professor Toynbee rejects the theory that civilizations are products of their surroundings and makes no scientific analyses of geographical factors, he constantly harps on the environment.

Volume I opens with an eloquent warning against the relativity of human thought, particularly against nationalism and industrialism. These, the writer considers, are the outstanding characteristics of Western civilization and cloud the present outlook. Here one misses the emphasis laid on scientific thought by F. S. Marvin and others. Surely in the West this is the dominating spirit and religion of the age?

Passing on, Professor Toynbee reviews and classifies civilizations throughout the whole extent of historical time and with the earth as his stage. He does not define societies as political or national units. Each, he maintains, is a "social atom," characterized by a "Völkerwanderung" or time of troubles, by a "universal church," and by a "universal state." On this basis he presents a list of 21 societies, 14 of which are dead and 7 still alive. Three—the Egyptian, the Sumeric, and the Minoan—go back to the dawn of history. Nevertheless, he considers that the species, which covers about 6000 years, is "very young in terms of its own time scale." Some of the societies are or were affiliated with others in various ways. A few are wholly unrelated. Brilliant and guarded as the argument is, the question arises how far many of the conclusions regarding the earlier societies can rest on fact. One is reminded of those critics of Dr. Ellsworth Huntington who pertinently ask whether his theories on the history of climate in classical times are based on the detailed statistics of a Roman weather bureau.

The sections that follow are very important to the geographer; for they deal with the genesis and growth of civilizations, the examination and rejection of the racial and environmental theories, and the development of the central thesis of "challenge and response." Seeking for the positive factor that shakes mankind from the "Yin-state" or "Integration of Custom" into the "Yang-activity" or "Differentiation of Civilization," the author joins with Plato in exposing that "noble lie," the "fallacy of race." He considers that the environment theory of the genesis of civilizations is less morally repulsive than the race theory, but not less vulnerable, though he pays close attention to the climatic theories of Dr. Ellsworth Huntington. The argument against these racial and environmental theories follows in general the lines of sociologists such as Sorokin. It may be questioned whether the archeological.

*A. J. Toynbee: A Study of History, Vols. 1–3, issued under the auspices of the Royal Institute of International Affairs, Oxford University Press, London, New York, etc., 1934; 2nd (revised) edit., 1935. These volumes represent about one-third of Professor Toynbee's projected study.

anthropological, historical, geographical, and biological data are as yet enough for conclusions so definite.

Having disposed of race and environment, Professor Toynbee unfolds his central thesis that civilization evolves from challenge and response and supports his theory by a magnificent survey of the stimuli of hard countries, new ground, pressures, penalizations, and blows. As throughout the whole work, geographers will note with appreciation that environmental influences carry great weight. The author reaches the conclusion "that civilizations come to birth in environments that are unusually difficult and not unusually easy . . . the greater the challenge the greater the stimulus [within limits] . . . the most stimulating challenge is to be found in a mean between a deficiency of severity and an excess of it."

This principle is applied in the third volume, which deals with the growth of civilizations. Once again in dealing with the increasing command over the human and physical environments and the interrelations between the individual and the growing civilization great importance is attached to the interplay between humanity and the environmental controls. With a wealth of scholarship and delightful style Professor Toynbee unravels the meaning of a tangled skein of fossil or growing civilizations, of penalized minorities, and of human Utopias, from Plato's "Republic" to Aldous Huxley's "Brave New World." Not least interesting is the examination of the curious phenomenon of "Withdrawal-and-Return." By this process the greatest spirits of all ages—Moses, Christ, St. Paul, the Buddha, Mohammed, Confucius, Caesar, Kant, Peter the Great, Lenin, and others—have withdrawn from society to realize their individual potentialities and have returned with transfigured personalities and powers. The author concludes from his survey that an individual, a minority, and a whole society achieve growth when they reply to a challenge by a response that not only answers that particular challenge but also exposes the respondents to fresh challenges that demand fresh response.

The volume concludes upon a philosophical note: "the variety that is manifested in Human Nature and in human life and institutions is a superficial phenomenon which masks, without impairing, an underlying unity." The seeds that the sower sows are all of one kind. Whatever their separate destinies, they are all fulfilling the sower's purpose. "The differentiating Yang-movement of growth is leading towards a goal which is a Yin-state of integration." In the words of the Koran: "To Him return ye every one."

As has been said above, no worker in a specialized field can adequately review Professor Toynbee's thesis, yet ultimately its value will be determined by specialized research. Geographers will welcome the attention given to environmental factors, and most of them will doubtless agree with the author that neither as a whole nor in specific cases such as climate are environmental factors all-important. Specialists in many fields will, however, leave this book with an uneasy feeling that, although the treatment is amazingly comprehensive, it omits certain vital factors now being revealed by research. On the racial side, for example, the analysis is naturally imperfect. Little is known as yet of the germ plasm or of the germ-plasm cycle, if such a cycle exists. The scientific aspects of racial mixture—a vital matter in the genesis and growth of civilizations—constitute a problem that is only just now dawning upon human intelligence. What scientist can as yet dismiss with certainty the possibility that the evolution and greatness of Hellenic civilization were primarily due to a favorable blend of races? On the environmental side recent American research is indicating that the analysis of climate may still be inadequate, and it is already clear that no historical study can omit such factors as disease and diet. Although one concedes to Professor Toynbee the difficulty of viewing modern societies in proper perspective, the diversity of opinion on Mayan civilization—to quote only one example—indicates that adequate scientific knowledge of early societies may never be ascertained.

These criticisms do not affect the conclusion that Professor Toynbee has already made an outstanding contribution to historical study, a contribution that is to be augmented by the survey of other aspects of civilization—their contact, rhythm, and decline. In the words of R. H. Tawney: "It is difficult to lay down these initial volumes without feeling that posterity will place this work among the histories which have altered man's outlook on society and life." The author himself notes that the human mind continues to analyze facts until it is so beleaguered that it must sort them into a synthesis, and this study is a synthesis of profound value in emphasizing the immensity of historical phenomena, the continuity of history, and the insignificance of nationalistic studies as compared with the sweep of social evolution and progress. Nevertheless, the growth of scientific knowledge daily reveals the increasing number and complexity of the human and environmental factors that affect society, and until all the great controls are discovered and elucidated there remains the danger that generalizations are premature. Professor Toynbee's noble plan and method disclose a wider vision for future historians, but thousands of microscopic studies are essential before the origin, growth, and nature of human society lie open to a telescopic view. Perhaps, however, the reviewer has been trapped by the thought pattern of the present age.

THIRTY-SECOND ANNUAL MEETING OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS

THE Association of American Geographers met at St. Louis on December 30 and 31, 1935, and January 1, 1936, for its thirty-second annual meeting. The sessions were held in Wilson Hall on the campus of Washington University and in the Hotel Chase, under the presidency of Professor Charles C. Colby of the University of Chicago. An all-day field trip, covering metropolitan St. Louis, under the direction of Professor Lewis F. Thomas of Washington University, was offered for Sunday, December 29, and preceded by an instructive résumé of the urban geography of the city. A second field trip scheduled for Thursday, January 2, to visit part of the Ozark Highlands, was given up on account of bad weather.

The following officers were elected for 1936: William H. Hobbs, president; John K. Wright, vice-president; John E. Orchard, treasurer; Preston E. James, secretary; Claude H. Birdseye, councilor for one year (to fill out the new secretary's unexpired term); and Richard J. Russell, councilor for three years. Other members of the council for 1936 are Charles C. Colby, Wallace W. Atwood, and Kirk Bryan. Derwent Whittlesey continues as editor of the *Annals*. The council selected Syracuse as the place of the next meeting of the Association.

An unusually large number of papers were presented at the meetings. Exclusive of the presidential address and the five invited papers, which made up a symposium on "Land Utilization," 59 papers were read, of which 29 were by introduced speakers. So crowded was the program that one evening session was necessary; yet even with this extra meeting and with the rule that no introduced paper could be discussed from the floor there was scarcely time for sufficient discussion of the other papers. The council decided that in the future there must be selection of the introduced papers actually to be read, the others being placed on the program to be read by title only.

The presidential address, delivered at the annual banquet, was entitled "Changing Currents of Geographical Thought in America." Professor Colby traced the development of the geographical point of view from the period of the exploratory surveys of the West, through the era epitomized by the work of Ellen C. Semple, and down to the present. He described the evolution of the regional concept—the concept of area as a unit of study—and showed how, especially in the last ten or fifteen years, it has provided our geographers with a fundamental theory around which to organize their efforts. Most recently geographers have proceeded to the application of this theory to the practical problems involved in land-use planning, as is illustrated by the geographical contributions to the various agencies of state planning and to the Tennessee Valley Authority.

Symposium on Land Utilization

Five invited papers made up the symposium on land utilization, held on Wednesday morning. The first paper was by Lester E. Klimm on "A Revolution in Land Utilization and Settlement Forms—Clare Island and Inishturk, Irish Free State." Illustrating his study by beautifully colored photographs and by maps, Professor Klimm showed the distribution of settlements on these islands at the time of the earliest topographic survey, when the population was considerably larger than today. Subsequently, under competent direction, many of the inhabitants of these overcrowded areas were removed and resettled elsewhere, and there were important rearrangements of the settlement patterns on behalf of the people left behind. This paper provided a striking illustration of the fact that problems relating to the redistribution of people are not new but have been met and solved long before the present difficult period.

The second paper was by Henry M. Leppard (introduced), who has recently completed a long period of study and field work in Scotland. This paper dealt at length with the relative proportions of the areas in that country devoted to the various forms of land use.

The third paper, by Loyal Durand, Jr. (introduced), set forth in a fine series of well prepared maps the essentials of the contribution of geographers to state planning in Wisconsin. The mapped data of present land use provide a basis for delimitation of various problem areas and especially for distinguishing several areas of superficial similarity but actual dissimilarity. Dr. Durand's excellent work for the Wisconsin State Planning Commission was thus for the first time officially brought to the attention of geographers.

The fourth paper, by G. Donald Hudson (introduced), the chief geographer of the Tennessee Valley Authority, described the work of his department. With the aid of a mosaic of airplane photographs and a well trained crew of field men using automobiles, as much as 30 square miles or more of territory can be covered in a day. The field mapping is done in terms of a development of the fractional system, first used by V. C. Finch in his study of the Montfort area.

The fifth paper was a discussion by K. C. McMurry of the actual and potential contributions of trained geographers in the field of land-use planning. He pointed out that several other academic disciplines and outside agencies deal with the problems of planning. These other groups, however, all seem to approach the problem with a decidedly narrow bias—the agricultural experts seeing only the possibility of expanding agriculture; the foresters, of expanding the timberlands; the National Park Service, of preserving the wild game. The geographical point of view, which focuses attention on the many facets of individual areas or regions, is able more effectively to compile the data and to judge between the various competing kinds of use. He supported this contention with several examples. In conclusion he suggested that, if geographers wish to contribute successfully to this important work, their training must include a broader knowledge of allied subjects and especially much more actual training in methods of land inventory in the field than is at present included in most university curriculums.

Other Papers Dealing with Land Planning

Land planning in its various aspects was also the subject of ten other papers. Among those dealing with the results of the application of geographical technique to actual areas one by C. Warren Thornthwaite was outstanding. A detailed study of the annual and accumulated income from wheat production in Sheridan County, western Kansas, covering the years from 1912 to 1934 inclusive shows that only in 1920 did the combination of price and crop yield bring a substantial income to the farmers. The period since 1920 shows a slight net loss to the wheat farmers.

A paper by Preston E. James described the result of the impact of two opposed plans for the use of Jackson Hole, Wyoming (to be published in the *Geographical Review*). Charles M. Davis (introduced) presented a series of maps building up the picture of the land-use pattern of the sand plains of Michigan and suggesting a method by which the counties might be combined and reorganized on a realistic basis. Robert M. Glendinning (introduced) and Otto E. Guthe (introduced) presented two aspects of their work in planning the severance lines of the reservoirs now being built or planned by the Tennessee Valley Authority. George T. Renner gave a résumé of his work for the National Resources Committee in laying out the proposed divisions of the United States and selecting the regional capitals for the more efficient handling of federal business. Charles Gooze (introduced) gave a brief report on the progress of the work of land classification now being carried on in Washington. Otis W. Freeman discussed the question "Columbia River Development, Wisdom or Folly?"

Two papers in the general category of land planning dealt with field methods. One, by J. M. Trefethen (introduced), presented an interesting application of the "Rosiwal" principle of petrographic analysis to the reconnaissance of geographical areas. According to this principle it is possible to arrive at a very accurate measurement of the areas occupied by various mineral surfaces on a thin section by measuring the intercepts of these minerals on a series of linear transects. The statement was made that, when this method is applied to the study of a geographical area, the total length of the traverse lines should be at least one hundred times the average intercept of the differentiated types. A similar technique, utilized by the geographers of the Tennessee Valley Authority, was described by Malcolm J. Proudfoot (introduced).

Areal Studies

Ten papers were devoted to the description and interpretation of areas. One of the high lights of the meetings was the presentation by Ralph H. Brown of his study of the Roswell region, New Mexico (to be published in the *Geographical Review*). With the aid of a series of block diagrams he first gave a clear picture of the physical features of the area. Then he built up on this fundament the several layers of the occupance, demonstrating vividly the early rise and decline of orcharding and the later rise of cotton. The present-day landscape is made up of a complex of superimposed patterns, many of its features inherited from processes no longer active in the region.

A number of other significant papers appeared in this group. Helen M. Strong suggested a division of the United States into manufacturing regions based on data computed on a county basis. The maps proved to be especially revealing in those parts of the country where city maps of manufacturing show only blank spaces. J. Russell Whitaker's paper set forth a proposed regional subdivision of peninsular Ontario together with the criteria on which he based his conclusions. D. H. Davis gave another of his interpretations of self-contained and more or less unique communities, this time the communal settlement of Amana in Iowa. Sidman P. Poole (introduced) described the settlement patterns of southern Brittany. Two papers, one by Herman R. Friis (introduced) and the other by Howard H. Martin (introduced), dealt with the island of Sakhalin or Karafuto. Samuel N. Dicken (introduced) discussed the relation of ground water and settlement in the middle Sierra Madre Oriental of Mexico. Alice Foster (introduced) divided the Vega de Valencia, Spain, into its chief geoponic types. Roland M. Harper offered a statistical basis for the regional contrasts of Italy.

Papers on Population and Occupance Patterns

Eight papers were focused more directly on the patterns of population and settlement. Outstanding in this group because of the novelty of its approach, in this country at least, was the study by Fred B. Kniffen of the distribution of house types in Louisiana. Professor Kniffen described in considerable detail the actual steps he had followed in arriving at his rigorously empirical classification of types. His paper must not be passed over without a word of appreciation for this attempt to find a more objective method of delimiting culture areas and of commendation for the careful presentation of the evidence on which conclusions were based—a step all too commonly omitted from geographical papers.

Several other papers also dealt with the analysis of population and occupance patterns. Henry M. Kendall (introduced) demonstrated the incorrectness of the often-repeated generalization that the population of France is decreasing in rural areas and increasing in industrial areas. His series of maps showed that this generalization has so many exceptions that its value may be challenged. A. J. Wright

(introduced) brought out the importance of historical period in determining the town patterns of Ohio. Edna Scofield (introduced) sketched some of her conclusions regarding the origin of the occupance patterns of New England. Stanley D. Dodge continued his studies of the rise and decline of population in New England, dealing especially with the coast of Maine. Alfred W. Booth (introduced) presented the population patterns of another of the Wisconsin regions, the Southeastern Dairy Region. Harold B. Ward (introduced) discussed the development of transportation lines in the vicinity of Hamilton, Ontario. Samuel T. Bratton (introduced) attempted the measurement of geographical relationships in a small area.

Urban and Economic Studies

Four papers may be classed as urban and three as economic. Of the urban papers one by C. Langdon White dealt with the city of Cleveland, showing that in spite of the favorable position of this city between the sources of iron ore and of coal it was handicapped in the development of its steel industry by the difficulty of getting the ore boats up the narrow, winding Cuyahoga River and the difficulty of expanding the cramped industrial area. Olive Thomas (introduced) described the development of the urban patterns in Green Bay, Wisconsin, and the relation of that city to the Fox-Wisconsin route. Reuel B. Frost (introduced) presented a series of maps to show the growth of cities, decade by decade, along the south shore of Lake Erie. William Applebaum (introduced) suggested the use of the Sanborn insurance atlases as a means of constructing maps of urban population and land use.

Among the papers dealing with economic geography W. O. Blanchard's study of the flow of trade through the Panama Canal during its twenty years of operation represented a distinct contribution. Frances M. Earle (introduced) described the agricultural trends in Hokkaido. Esther S. Anderson (introduced) discussed the variability from year to year of crop and livestock production in Nebraska.

Papers on Geomorphology

Only six papers were devoted to the study of land forms. W. S. Cooper delighted the extra evening session with his beautiful colored motion pictures of the fiords of southern Alaska. His first paper, the opening one of the first day, given with W. O. Field, Jr., set forth some of the results of his glacial studies in this part of the world. He concluded that there is no evidence of a general recession of the glaciers in the last 500 years but that those glaciers actually in retreat are generally found to be in contact with deep sea water. He also suggested a new hypothesis for the formation of pits in outwash deposits. Richard J. Russell with the aid of a series of maps described the characteristic meander patterns of the lower Mississippi and shore lines of the delta country. W. E. Powers (introduced) and Charles H. Behre, Jr., interpreted the origin of South Park, Colorado, as the result of erosion on weak rocks and illustrated their story with an excellent series of block diagrams. Wallace W. Atwood, Jr. (introduced), exhibited two fine series of oil paintings by Eugene Kingman, one showing the stages in the evolution of the glacial and volcanic landscape of Mt. Mazama, Crater Lake National Park, the other the evolution of the Yosemite. Caspar Rappenecker (introduced) described the formation of a temporary karst lake in the Moneague Valley, Jamaica.

Meteorology and Climatology

The Tuesday morning session was held jointly with the American Meteorological Society and was devoted chiefly to papers on meteorology and climatology. Nine papers were read, two of them by J. B. Kincer dealing with the organization of climatological observations in the United States and with the work in climatology

and agricultural meteorology in certain countries of Europe. John B. Leighly's paper presented a method, based on monthly averages, for the more exact determination of the date and amount of maximum and minimum temperatures. In climatological studies where these matters are of critical importance this method will introduce a very significant refinement. A paper by Earl E. Lackey (introduced) dealing with the occurrence of frost in the Great Plains and one by John K. Rose (introduced) correlating corn yield and certain climatic variables in the Corn Belt were published in the January number of the *Geographical Review*. S. S. Visher exhibited a series of maps of various climatic features of Indiana bringing out the great difference in pattern between averages and extremes. This paper added to the growing recognition of the importance of extremes in climatological studies. Eric R. Miller (introduced) described the geographical distribution of the Brückner cycle in the United States and showed that while the Great Lakes states might be experiencing a peak of the cycle the southern states might be experiencing a trough. J. C. Jensen (introduced) reported on the results of an intensive study of the relation of thunderstorm precipitation to water bodies. C. J. Bollinger (introduced) showed that with cooler water in the Gulf of Mexico less rainfall was to be expected in the southwestern states.

Miscellaneous Papers

Nine other papers, of miscellaneous content, were given. Richard Hartshorne continued his work in the field of political geography, setting forth a suggested terminology for political boundaries and launching a vigorous attack against the conventional description of boundaries as "natural" or "artificial." Guy-Harold Smith read a delightfully phrased paper regarding the use of the term "Great American Desert" on maps of the United States. He showed how the earliest maps carried this designation on the southern Great Plains and how the name migrated westward in front of advancing settlement until it jumped across to the west side of the Rocky Mountains. Wellington D. Jones pleased the audience with a lively discussion of the use of various kinds of ratios between crops, areas, and people in the construction of isopleth maps. Mark Jefferson presented another of his stimulating papers, entitled "Motors as Criteria of Wealth in Europe, 1934." J. W. Hoover discussed the Navajo land problem; William H. Haas gave an account of a little-known American citizen, the Jíbaro; Edwin N. Humphrey (introduced) discussed map projections; and E. C. Prophet (introduced) presented a suggested classification and terminology for recreational land use.

A memorial to Curtis F. Marbut, written by H. L. Shantz, was read by the secretary.

Preston E. James

AMERICAN GEOGRAPHICAL SOCIETY

The December Meeting. The regular monthly meeting of the American Geographical Society was held on December 17, 1935, at the Engineering Societies' Building, 29 West 39th Street, Mr. R. R. Platt, Secretary of the Society, in the chair. Dr. Robert Cushman Murphy, Curator of Oceanic Birds at the American Museum of Natural History and a contributing editor of the *Geographical Review*, introduced the speaker of the evening, Dr. George Miksch Sutton of the Laboratory of Ornithology at Cornell University. In 1929–1930 Dr. Sutton spent a year with the Eskimos of Southampton Island in Hudson Bay, and his lecture, entitled "A Year in the Arctic with Brush and Camera" and illustrated with motion pictures and colored lantern slides made from his own paintings, dealt with his study of the birds and animals of the island and the intimate life of its Eskimo inhabitants. Dr. Sutton has told the story of his experiences in "Eskimo Year" (New York, 1934).

The January Meeting. The Annual Meeting of the Society was held on January 21, 1936, at the Engineering Societies' Building, 29 West 39th Street, President Redmond presiding. After the reading of a brief summary of the Annual Report (printed below) and the election of officers and councilors for 1936 Colonel Theodore Roosevelt presented Mr. C. Suydam Cutting, who delivered a lecture on his expedition to Central Tibet in 1935. Mr. Cutting has accompanied and personally conducted a number of important expeditions to Central Asia. In 1935, with Mr. Arthur S. Vernay, he carried out an expedition to Central Tibet for the American Museum of Natural History, visiting the little-known cities of Shigatze and Lhasa on special invitation from the Tibetan authorities. The motion pictures with which his lecture was illustrated included remarkable pictures of Shigatze and Lhasa and of the life in their great lamaseries and also pictures of Chinese Tibet taken on the Kelly-Roosevelt-Field Museum Expedition in search of the giant panda, of which he was a member.

The February Meeting. The regular monthly meeting of the Society was held on February 25, 1936, at the Engineering Societies' Building, 29 West 39th Street, Mr. R. R. Platt presiding. Mr. Amos Burg delivered a lecture entitled "Voyaging Fuegian Seas for Cape Horn." Mr. Burg with a single companion made a trip in 1934 in a 26-foot boat through the Strait of Magellan and down to Cape Horn. The motion pictures with which his lecture was illustrated included pictures of the life of the last remnants of the Yahgan and Alacaluf tribes of the Patagonian archipelago, of settlements and sheep ranches on Tierra del Fuego and the Brunswick Peninsula, and of the snow-capped peaks and glaciers bordering the Beagle Channel and many of the other channels traversed on the voyage.

Elections of Fellows. At the December, January, and February meetings of the Council of the Society the names of 458 candidates were presented who were duly elected as Fellows of the Society.

Award of the David Livingstone Centenary Medal for 1936 to Lincoln Ellsworth. The Council of the Society at its meeting on January 21, 1936, unanimously approved the award of the David Livingstone Centenary Medal to Mr. Lincoln Ellsworth in recognition of his contribution to geographical knowledge by his flight across the Antarctic Continent from Dundee Island to the Bay of Whales (see the note under "Geographical Record" in the present number of the *Geographical Review*). Notice of the award was sent to Mr. Ellsworth by radio, and on January 22 Mr. Redmond, President of the Society, received from Mr. Ellsworth the following radiogram sent from his supply ship, the *Wyatt Earp*: "Please accept and convey to the members

of your Council my sincere appreciation of the distinguished honor conferred upon me in the award of the David Livingstone Centenary Medal. Throughout all my efforts I have highly valued the coöperation and assistance of the American Geographical Society."

On March 2, in a two-way radio conversation between Dr. John H. Finley, Honorary President of the Society, from Schenectady, N. Y., and Mr. Ellsworth, from Sydney, Australia, the medal was formally awarded and accepted.

The "Bibliographie Géographique Internationale" for 1934. The forty-fourth issue of the *Bibliographie Géographique Internationale* is now ready for distribution in the United States by the American Geographical Society. It is published by the Association de Géographes Français with the collaboration of the American Geographical Society, the Comitato Geografico Nazionale Italiano, the Geographische Gesellschaft in Wien, the Royal Geographical Society (London), the Société Belge d'Études Géographiques, and the Société Royale de Géographie d'Égypte. The material listed is critically selected, and brief critical notes or references to reviews in outstanding geographical periodicals are added to many of the titles. Current publications—books, periodicals, government and state publications, and maps—are included.

ANNUAL REPORT OF THE COUNCIL

January 21, 1936

To the Fellows of the Society:

On July 1, 1935, Dr. Isaiah Bowman, for twenty years Director of the Society, resigned to accept the presidency of the Johns Hopkins University.

The Society has been rarely privileged in having at its head for so long a term of years one who is equally scholar and administrator, man of vision and man of action. When, in 1915, Dr. Bowman was invited to become the first director of the Society, the activities of the institution were chiefly confined to the maintenance of a library and a map collection, an annual lecture program, the publication of a monthly *Bulletin*, and the awarding of medals and other honors. Dr. Bowman was appointed Director for the express purpose of enlarging the Society's activities. That the Society stands today at the forefront among geographical societies the world over and has won general recognition as one of the most productive among institutions devoted to scientific research is a tribute to his creative imagination and his genius for putting ideas into effect. The change of the name of the Society's journal from "Bulletin" to "Geographical Review" and later its conversion from a monthly to a quarterly publication signaled the endeavor to broaden its range and deepen its intellectual interest. The reorganization of the Society's library and map collections likewise expressed the purpose of extended and intensified usefulness to staff and public. Since 1915 the library collection has been more than doubled and the map collection nearly tripled.

Up to 1915 the Society's publications were virtually limited to the monthly bulletin. The *Research Series*, the *Special Publications*, and other publications produced since 1915 comprise some thirty-five volumes in addition to a large number of specially prepared maps. Their range is expressive, revealing "the pervading soul of the geographer that sees the basic bearings of the frame of the earth and the physical as well as social ties of its inhabitants." The series of book publications was happily started with Dr. Bowman's report on his field work in Peru, "The Andes of Southern Peru," which another adventurer in high places, Theodore Roosevelt, described as "one of those uncommon books in which a man who has had the vision to undertake adventure and the hardihood to carry it through sets forth with wisdom what he has seen." This conception of the geographer's duty to explore the unknown

earth continued as a prime objective of the Society under Dr. Bowman's directorship. As instances of one phase of the Society's promotion of exploration may be cited our publications on the problems of the polar regions, our maps of the Arctic and Antarctic, and the aid we have given to Wilkins, Byrd, Ellsworth, Mawson, and the Norwegian explorers of the Antarctic.

But this advance on the physical frontiers was not enough. From the first Dr. Bowman had a parallel aim for the Society—the ideal of public service and our duty as a national institution concerned with national welfare. The opportunity for such service came soon after his appointment as Director. In 1918 building, staff, and collections were put at the disposal of the government for "The Inquiry" to prepare for peace, and Dr. Bowman himself acted as Chief Territorial Adviser to the Peace Conference in Paris. No book has brought the Society more honor than "The New World," an outcome of these experiences in international affairs. Since that time the Society has frequently been called on to aid the Department of State in matters of political geography, notably in various Central and South American boundary disputes—Guatemala-Honduras, Tacna-Arica, and the Bolivia-Paraguay dispute in the Chaco. Indirectly we may count of service, also, the friendly relations established with the Hispanic American republics through the Society's program of Hispanic American research, involving primarily the map of the whole region on the scale of 1 : 1,000,000, a project that has been termed "the greatest single piece of work ever undertaken by a geographical institution."

It was through contributions from the Society that the *Bibliographie Géographique Internationale*, that indispensable tool of the geographer, was saved at a crucial moment and later assisted in securing international support for its maintenance.

Peculiarly fitting, therefore, was the election of Dr. Bowman to the presidency of the International Geographical Union and the Congress that met at Warsaw in 1934.

No less earnest has been Dr. Bowman's insistence on the geographer's duty toward education. This has been reflected in various ways. The Society, for instance, took over the publication of the *Journal of Geography* at a critical time, eventually to turn it over to the National Council of Geography Teachers when that body was firmly organized. A more recent expression of this interest in education is Dr. Bowman's service on the Commission on the Social Studies in the Schools. His volume on "Geography in Relation to the Social Sciences" in the series issued by this Commission was aimed to give scholars in the separate fields "a better understanding of how each may contribute to the other for the general improvement of society."

"Specialized knowledge has an all too limited use if the investigator is ignorant of the related knowledge of his colleagues in adjacent fields." Under Dr. Bowman's administration the Society has maintained effective coöperation with individuals and institutions representing a wide diversity of interests and functions. Among the fruits of this coöperation are the regional study of New England problems, the "Atlas of Historical Geography of the United States" published jointly with the Carnegie Institution of Washington, the Colorado Delta and Great Basin studies with the Carnegie Institution, and the coastal-terrace studies with the Carnegie Institution and Columbia University. The value of coöperative research is nowhere better exemplified than in the pioneer-settlement studies initiated by the Society with the endorsement of the National Research Council and the support of the Social Science Research Council mentioned elsewhere in this report.

For two years during his directorship at the Society Dr. Bowman served as Chairman of the National Research Council and as Vice-Chairman and Director of the Science Advisory Board created in 1933 to advise the government on scientific matters. Among the important recommendations to which the Society has made contributions are those dealing with weather and climatic risk, land use and soil erosion, mapping and survey. Thus the Society has been able to participate in an undertaking of the utmost importance to the nation.

In these varied activities—and they represent only a part of the Society's sphere of action—Dr. Bowman not only has furnished the inspiration but has carried a large share of the burden of achievement.

The Geographical Review

The late tendency to "arraign science before the bar of public opinion," as one writer has put it, has the merit of causing the scientist to inquire into the philosophy and method of his work. It has been the privilege of the *Geographical Review* to publish such an inquiry by the distinguished Norwegian biologist, Dr. Johan Hjort, who takes "Human Activities and the Study of Life in the Sea" as the subject of an essay on methods of research and experimentation and their social application. "How far can science go?" asks Dr. Isaiah Bowman in an inquiry into the occupation of our submarginal western lands. His study of climatic risk in "Our Expanding and Contracting 'Desert' " is illustrative of the studies on pioneer settlement and kindred problems of land utilization initiated at the Society more than a decade ago. Among undertakings more or less indebted to the Society's studies are those of the Canadian Pioneer Problems Committee and the Land-Use Committee of the Science Advisory Board. The findings of the Canadian Pioneer Problems Committee are now in process of publication, and a survey of the volumes that have already appeared is made by H. A. Innis of the University of Toronto. The report of the Science Advisory Board, "Land Resource and Land Use in Relation to Public Policy" (by Carl O. Sauer), and the report of the National Resources Board are discussed by W. L. G. Joerg under the title "Geography and National Land Planning." Articles dealing with specific cases of settlement and land utilization in North America cover the Peace River Country, the Red River of the North, a submarginal community in Minnesota, and the evolution of a New Hampshire town (with insert plate of maps in color). Studies of climatic boundaries in the eastern United States, the forest cover in Wisconsin, and the relation between deforestation and floods in southern California are also presented from the land-utilization angle. Unrealized possibilities on the northeastern seaboard of Mexico are described by a Russian agricultural explorer. Types of occupation on another frontier, the coffee lands of Brazil, also are dealt with, and one might perhaps describe as a frontier study Dr. A. Grenfell Price's inquiry into the achievements and prospects of white settlement in the Panama Canal Zone.

A group of papers has its locus in Asia. A member of the Inspectorate of Salt Revenue of China discusses the salt monopoly that affects four hundred million consumers and plays so important a part in the domestic, commercial, and political life of China. The problems of the port of Tientsin, the leading port of North China, furnish another Chinese theme. In his analysis of the 28-volume report on the census of India for 1931 Dr. G. Findlay Shirras of Gujarat College of the University of Bombay gives a view of the magnitude and intricacy of the Indian population problem. Two papers deal with explorations at the opposite extremities of the Asiatic continent: explorers of the U. S. S. R. have greatly increased our knowledge of "The Mountain Systems of Northeastern Asia," and a German explorer has made "The First Crossing of Southwestern Arabia."

Another group of papers is concerned with the origin, migrations, or civilization of ancient peoples—"The Spread of Aboriginal Man to North America," "Eskimo Migrations in Greenland" (Dr. Therkel Mathiassen of the National Museum of Copenhagen sums up the results of many years of field work), "The Ancestors of the Tuaregs" (by E. F. Gautier of the University of Algiers), "Ancient Civilizations of the Santa Valley and Chavín" (with notable photographs of these Peruvian sites). Of historical interest are "The So-Called Bartholomew Columbus Map of 1506" by John Bigelow and Dr. Adolf Hoel's "The Discovery of King Karl Land, Spitsbergen."

Captain N. H. Heck of the U. S. Coast and Geodetic Survey presents "A New Map of Earthquake Distribution" (insert in color), which has aroused much interest. Other contributions consider earthquakes as a cause of glacier avalanches in the Caucasus and connect ice floods with volcanic eruptions in Iceland. Excursions in the field of physical geography include theoretical considerations of world precipitation distribution, the interpretation of certain distinctive physiographic features of the Mississippi delta, and bathymetric studies of Lake Michigan. A quantitative analysis of insolation in relation to topography in the Alps is presented in its bearings on the distribution of human settlements. A type of map new to America represents the relative relief of Ohio. A map in color of the Nain-Okak region of Labrador continues northward the author's map of 1930 and connects with the Society's map of northern Labrador now in course of publication.

Two new fields of geographical inquiry are introduced in studies of "The Business of Recreation" and cruising by airplane. The latter, by Dr. R. U. Light, is illustrated with a selection of the beautiful photographs taken by him on his round-the-world journey and donated to the American Geographical Society.

New Books

During the year editorial work was completed on "Chile: Land and Society," by Dr. George M. McBride, and the book was published in January, 1936. Dr. McBride, a former member of the staff of the Society and now professor of geography at the University of California at Los Angeles, is an authority on questions of land tenure in Hispanic America. The Society published in 1921 a short study by him on "The Agrarian Indian Communities of Highland Bolivia" and in 1923 a volume on "The Land Systems of Mexico." His present work is based on personal observations during long residence in Chile and on research in Chilean libraries, archives, and government offices, carried out with the support of the Society.

There is now in press and will be ready for distribution shortly a volume entitled "The Colorado Delta," by Mr. Godfrey Sykes, which the Society is publishing jointly with the Carnegie Institution of Washington. Mr. Sykes, who has been associated with the Desert Laboratory of the Carnegie Institution at Tucson since its establishment in 1903, has been a close observer of the delta for the past 45 years. From 1929 to 1934 he made a special study of it under the joint sponsorship of the Society and the Carnegie Institution.

Department of Hispanic American Research

Ten new sheets of the Map of Hispanic America on the scale of 1 : 1,000,000 on which the Society has been engaged for the past 14 years have been published, bringing the total of published sheets to 60. The drafting work is now nearly completed, and the drawings for the remaining 42 sheets are going to the lithographer as rapidly as the final editing can be completed. It is expected that the publication of the entire map will be finished in July, 1936.

A volume in which will be discussed the source material assembled for the map and the manner in which it was built into the compilation is in preparation and will be published by the end of 1936.

Work is well advanced on reductions of the published sheets and compilations that are being made in preparation for the publication of a map of Hispanic America on the scale of 1 : 5,000,000. This map will be issued in two editions, an edition with hypsometric tints for general reference use and one without hypsometric tints for use in plotting distributions and other general research purposes. The reductions and necessary generalizations carried out by the compilers of the original sheets of the Millionth Map will provide in wall-map size as accurate and detailed a small-scale general map of the whole area as present cartographic knowledge will permit.

Department of Technical Training

The department continued during the year its consulting service to expeditions and individuals on mapping methods and field equipment. Assistance and advice were given to a number of expeditions in planning their technical programs, and instruments were lent to six field parties.

The chief activity of the department, however, has been the continuation of its program of research and experimentation in aerial survey methods. The method of mapping by means of high oblique aerial photographs developed in the department and the instruments devised in connection with it have attracted wide attention. The head of the department was invited to address several meetings of optical and photogrammetrical experts during the year, and articles on the method appeared in a number of technical journals. The first sheet of the topographical map of some five thousand square miles in northern Labrador that is being constructed by this method from oblique aerial photographs taken on the Grenfell-Forbes Expedition of 1931 was completed during the year and was published in the January, 1936, number of the *Geographical Review*. Good progress was made on the remaining sheets of the map, the work being greatly expedited by the use of an instrument for plotting semi-automatically from oblique photographs, designed on a new optical principle by the head of the department. This instrument is the only one of its kind in existence. It is the property of the designer and Mr. George A. Thorne, Jr., who have lent it to the Society for experimentation.

In connection with the program of research in aerial surveying Mr. Walter A. Wood, Jr., a member of the staff of the department, organized and carried out during the summer of 1935 an expedition to a little-known part of the Yukon region. Oblique aerial photographs of a large area were made for use in the construction of a map, ground control was established, and in addition Mt. Steele (16,644 feet) was ascended for the first time. A preliminary report on the work of this expedition is published in the present number of the *Geographical Review*.

Dr. Alexander Forbes, leader of the Grenfell-Forbes Labrador Expedition of 1931, accompanied by Mr. Charles J. Hubbard as pilot, made a flight from Boston to Cape Chidley and return during the summer of 1935 for the special purpose of filling in gaps in the aerial photographs taken on the 1931 expedition.

Library and Map Collections

During the year 674 books, 739 pamphlets, 932 volumes of periodicals, 2518 maps, 97 atlases, 986 photographs, and 91 lantern slides were added to the Society's collections. The collections now consist of 102,031 volumes of books and periodicals, 17,895 pamphlets, 91,734 maps, 1815 atlases, 10,716 photographs, and 1554 lantern slides.

Attention is called to the fact that, in spite of drastic curtailment of funds for the library and map collections necessitated by serious reductions in the Society's income during the financial depression, it has been possible to continue the upbuilding of the collections. This has been due to constant attention on the part of the staff to exchanges and the solicitation of new publications from publishers and authors and to gifts from friends of the Society interested in maintaining its position as the repository of one of the world's most important collections of geographical publications.

Among the gifts to the library in 1935 are: Curtis' "Nile Notes of a Howadji," 1856, Harper's "School Geography," 1880, Houston's "Elements of Physical Geography," 1897, and Maury's "Physical Geography," 1897, from the Huntington Free Library and Reading Room; 56 pamphlets dealing especially with geology from Columbia University; 18 guidebooks from Dr. F. A. Blossom; Balch's "North Pole and Bradley Land," 1913, Balch's "Mount McKinley and Mountain Climbers' Proofs," 1914, and Smith's "History of Greece," 1860, from Mrs. John Greenough;

Bergt's "Beitrag zur Petrographie der Sierra Nevada de Santa Marta," 1888, and Sievers' "Reise in der Sierra Nevada de Santa Marta," 1887, from Dr. J. A. Kerr; "Libros de cabildos de Lima," 1935, 5 vols., "Monografías históricas sobre . . . Lima," 1935, 2 vols., Mugaburu and Mugaburu's "Diario de Lima, Vol. II," 1935, Porras Barrenechea's "Pequeña Antología de Lima," 1935, and Suardo's "Diario de Lima (1629–1634)," 1935, from the Concejo Provincial de Lima; "Bremen und seine Bauten," 1900, Barnes's "Our Greatest Mountain," 1911, and Baud-Bovy's "Wanderungen in den Alpen," 1899, from Miss Dorothea Hering.

Notable among the gifts to the map collection are: Six manuscript weather maps of North America from Dr. Irving Krick; 15 topographic sheets from the Metropolitan Water District of Southern California; 4 atlases from Rand McNally and Company; "Atlas de la France et de ses Colonies," from *L'Illustration;* "Atlas des Colonies Françaises," from Société d'Éditions Géographiques, Maritimes et Coloniales; 36 maps from the Iowa State Planning Commission; 46 sheets of an air navigation map from the Australian Department of Defence; 7 maps and "The Citizen's Atlas" from John Bartholomew and Son, Ltd.; 4 charts of the Antarctic from Hvalfangernes Assuranceforening; 8 maps of New York from the Mayor's Committee on City Planning; 18 geological maps of Madagascar from the Madagascar Department of Mines; 11 maps and 2 historical atlases from Denoyer-Geppert Company; "Atlas of European History" and "Atlas of Current World Affairs," from Alfred A. Knopf; topographic surveys from the governments of the Argentine Republic, Canada, Czechoslovakia, Denmark, Egypt, Finland, France, Germany, Great Britain, Hungary, India, Japan, Nigeria, Norway, Poland, Anglo-Egyptian Sudan, Sweden, Union of South Africa, and the United States; and hydrographic charts from the Argentine Republic, Italy, Great Britain, Canada, Sweden, Norway, Denmark, the Port Commissioner of Rangoon, and the United States.

Among the additions to the photograph collection were: Seventy-one photographs of Mt. Pelée from Dr. F. A. Perret; 114 European photographs from Miss Louise A. Boyd; 40 photographs of Persia from Mr. F. G. Clapp; 57 aerial photographs from Dr. R. U. Light; and 23 albums of European photographs and 49 photographs of the western United States from Miss Dorothea Hering.

More than 7000 titles of books, periodical articles, and maps were added to the research catalogue. In addition to the large number of telephone calls and written requests for information, attention to which forms a considerable part of the work of the library staff, the library was personally consulted by about six hundred persons. During the year a chronological guide to geographical periodicals was prepared, and special attention was given to the development of the photograph collection. This collection, now in its infancy, the Society hopes to build up to a representative collection of geographical photographs of all parts of the world for research and illustrative use, and contributions to it are earnestly solicited.

The library continued its coöperation with the Association de Géographes Français in the preparation of titles and abstracts for the *Bibliographie Géographique Internationale.*

Coöperation in Other Enterprises

The Society was represented at the annual meeting of the Association of American Geographers at St. Louis, December 29 to January 1, and a report on the meeting was prepared for the April number of the *Geographical Review.*

The Society was also represented at the annual meeting of the National Research Council and at the Congress of the Pan American Institute of Geography and History held in Washington, October 18–23. The head of the Department of Technical Training, Mr. O. M. Miller, read a paper before the annual meeting of the Optical Society of America at New York, February 22–23, on the optical principle of the plotting machine that he has devised for use with the Society's method of mapping

by oblique aerial photographs and reported on the development of the method at a meeting of the American Society of Photogrammetry at Washington, April 22–23.

The Society's coöperation with the Science Advisory Board, on which Dr. Isaiah Bowman, while Director of the Society, served as Vice-Chairman and Director, continued to its expiration on July 31, 1935 (later extended to December 1, 1935). An outgrowth of the special attention given by Dr. Bowman to the work of the Land-Use Committee of the Board was his address on "The Land of Your Possession" before the American Association for the Advancement of Science at Minneapolis in June. This address is published in the final report of the Board, to which Mr. W. L. G. Joerg, editor of the Society's *Research Series*, contributed a survey of research problems in natural science bearing on national planning and a summary of recent reports on natural resources, which was based on the article on "Geography and National Land Planning," in the April, 1935, number of the *Geographical Review*.

These land-use studies as well as Dr. Bowman's article "Our Expanding and Contracting 'Desert' " in the January, 1935, number of the *Geographical Review*, are rooted in the pioneer-settlement studies initiated by the Society a decade or more ago. One important aspect of this program was the work done in Canada by the Canadian Pioneer Problems Committee on the Society's recommendation and with the support of the Social Science Research Council. The results are being published in a series of nine volumes entitled "Canadian Frontiers of Settlement" under the joint editorship of Dr. W. A. Mackintosh of Queen's University, Kingston, chairman of the committee, and Mr. Joerg of the Society's staff. In addition to the two volumes referred to in the Annual Report for 1933, two further volumes have been published, "Economic Problems of the Prairie Provinces," by Dr. Mackintosh, and "Agricultural Progress on the Prairie Frontier," by Dr. R. W. Murchie of the University of Minnesota, formerly of the University of Manitoba. A fifth volume is in press, "Group Settlement: Ethnic Communities of Western Canada," by Dr. C. A. Dawson of McGill University.

On invitation of the Canadian Geographical Society and the University of Toronto, the Society was represented at the ceremonies on November 7 in connection with the establishment of a Chair of Geography at the University of Toronto—the first such chair in the Dominion—and the inauguration of Professor Griffith Taylor, formerly of the University of Sydney and recently of the University of Chicago, as incumbent.

Award of Honors

At the monthly meeting of the Society on November 26, 1935, the following medals were awarded:

The Charles P. Daly Medal to Dr. Roy Chapman Andrews, director of the American Museum of Natural History, in recognition of his work as organizer and leader of the Museum's expeditions to Central Asia from 1916 to 1930.

The Cullum Geographical Medal to Dr. Douglas Johnson, professor of physiography at Columbia University, in recognition of his contribution to physiographic research and in particular for his studies of shore-line processes and development.

The David Livingstone Centenary Medal to Consul Lars Christensen in recognition of his promotion of Antarctic exploration in connection with the Norwegian whaling industry, in which he is the principal figure.

Three Honorary Members were elected in 1935: Rafael Aguilar y Santillán, general secretary, Sociedad Mexicana de Geografía y Estadística, Mexico City; Dr. Alexander Forbes of the Harvard Medical School; and William A. Mackintosh, professor of political and economic science, Queen's University, Kingston, Ontario.

The following were elected Honorary Corresponding Members: Hans W:son Ahlmann, professor of geography, University of Stockholm; Carlos M. Delgado de Carvalho, professor of social sciences, Colegio Pedro II, Rio de Janeiro; Charles C.

Colby, professor of geography, University of Chicago, and president for 1935 of the Association of American Geographers; O. G. S. Crawford, archeology officer, British Ordnance Survey; Charles B. Fawcett, professor of economics and regional geography, University of London; Nevin M. Fenneman, professor of geology and geography, University of Cincinnati; Lawrence Martin, chief, Division of Maps, and incumbent, Chair of Geography, Library of Congress; Carl O. Sauer, professor of geography, University of California; Camille Vallaux, former professor of geography, École des Hautes Études Commerciales, Paris.

Lecture Program

During the past year the speakers and titles on the Society's lecture program were as follows: Dr. George B. Cressey, "The Chinese Landscape"; Mr. Bertram Thomas, "Native Life and Exploration in Arabia"; Captain Peter Freuchen, "The Eskimos as I Know Them"; Dr. Robert Cushman Murphy, "Mountain and Seacoast in Ecuador"; Consul Lars Christensen, "Recent Norwegian Exploration in the Antarctic"; Dr. George M. Sutton, "A Year in the Arctic with Camera and Brush."

Election of Honorary President

At the Annual Meeting of the Society on January 24, 1935, Dr. John H. Finley, who served as ninth president of the Society, from 1925 to 1934, was elected Honorary President.

Report of the Treasurer

The Council has received a report from the Treasurer giving a summary of the income and expenses of the Society, and the accounts of the Society have been audited by certified accountants, whose report is on file at the office of the Society.

PHILIP W. HENRY, *Chairman*

REPORT OF THE SPECIAL COMMITTEE

New York, January 21, 1936

The committee appointed at the meeting of the Council held on December 18, 1935, to nominate officers for the vacancies to occur in the Council in January, 1936, beg to nominate the following named gentlemen for the offices designated and move that the same be approved and presented to the Society for election at its meeting to be held on January 21, 1936.

		Terms to expire in
President	Roland L. Redmond	January, 1937
Vice-President	Oliver B. James	January, 1939
Foreign Corresponding Secretary	Frederic C. Walcott	January, 1939
Treasurer	Henry Parish	January, 1937
Councilors	H. Stuart Hotchkiss Arthur Curtiss James	January, 1939
	Frank L. Polk Frederick Hellmann	

Philip A. Carroll
William A. Rockefeller } *Committee*
Carl C. Shippee

GEOGRAPHICAL RECORD

NORTH AMERICA

Exploration of the Coast Range of British Columbia. "A comparatively short distance from a sky-scrapered city there lies a vast region of fine peaks, great glaciers, snowfields and forests, as yet practically unknown" (E. B. Beauman: A Crossing of the Coast Range of British Columbia, *Alpine Journ.*, Vol. 47, 1935, pp. 75–86). It is only 14 years ago that Mt. Waddington, 13,260 feet, the highest known peak of the Coast Range of British Columbia (excluding the boundary peak, Mt. Fairweather), was first sighted and 10 years ago that the first attempt was made to reach it, though the mountain lies only 175 miles from Vancouver and 24 miles from tidewater. The story of the explorations of 1926 and 1927 has been told in the *Geographical Review* (W. A. Don Munday: Explorations in the Coast Range of British Columbia, *Geogr. Rev.*, Vol. 18, 1928, pp. 196–214; see also G. G. Aitken: Waddington Mountain, the Highest Peak in British Columbia, *ibid.*, Vol. 19, 1929, p. 150). In 1928 W. A. Don Munday and his party succeeded in climbing the northwest peak of the mountain.

On these first attempts the approach was made from tidewater. In 1931 Henry S. Hall, Jr., began an investigation of the landward approaches, which was continued in 1932 and 1933 and resulted in a thorough reconnaissance of the northern parts of the range (H. S. Hall, Jr.: Further Exploration and Ascents in the Coast Range of British Columbia, *Amer. Alpine Journ.*, Vol. 2, No. 2, 1934, pp. 156–169). In 1934 no fewer than four parties were in the field (R. M. Leonard: Attempts on Mount Waddington, *Appalachia*, Nos. 79–80, 1935, pp. 336–340). One of them crossed the Waddington Range on skis; another, in which one life was lost, attempted the southeast ridge of the highest peak; another attempted the northeast face; and Mr. Hall, who had joined forces with the Mundays and Hans Fuhrer, made the second ascent of the northwest peak. Mr. Hall's narrative of the ascent (The 1934 Attempts on Mt. Waddington, *Amer. Alpine Journ.*, Vol. 2, No. 3, 1935, pp. 298–306; see also the same: Climbs in the Coast Range of British Columbia, *Alpine Journ.*, Vol. 47, 1935, pp. 288–299) is accompanied by a sketch map by Mr. Munday on the scale of about 1 : 200,000, which revises the map of the great ice system published in the April, 1928, number of the *Geographical Review*.

The most recent chapter in the history of the mountain was written in 1935 when a party from the Sierra Club, after failing in two attempts on the southwest face, completed the third ascent of the northwest peak. Speaking of the Alps, A. F. Mummery once said that all mountains therein chronologically pass through three mountaineering stages—an inaccessible peak, the most difficult climb in the Alps, an easy day for a lady. Applied to Mt. Waddington, this peak, despite thirteen attempts in a period of nine years, still remains in the first stage of mountaineering history—certainly a record in North American climbing.

An Economic and Social Survey of the Southern Appalachians. The United States Department of Agriculture has published the results of a comprehensive survey of the Southern Appalachians (Economic and Social Problems and Conditions of the Southern Appalachians, *U. S. Dept. of Agric. Misc. Publ. No. 205*, 1935). The purpose was to provide various "agencies interested in the welfare of the people" with a factual basis for planning their programs. The region embraces the highland portions of the states between Alabama and Maryland as well as the great Appalachian valleys, an area considerably larger than New England. The sources of information used were for the most part published materials, and little was done in the way of field work; nor is any attempt made to suggest definite programs or

plans. Twelve investigators deal with matters of physiography and climate and with problems of land utilization, farm organization and management, markets, transportation, and manufactures, public finance, schools, population, standards of living, food supply, social conditions, and the church.

In a general introduction L. C. Gray and C. F. Clayton point out that the fundamental problems of the region have to do with maladjustments in land use and in the relation of population to the land. The Southern Appalachians may be split into three main parts: the plateaus, the Appalachian valleys, and the Blue Ridge mountains. From the social and economic points of view the plateaus and the mountains are characterized as "definitely pathological." The two principal problems are conceived to be (1) that of formulating an effective program for developing communities that will be dependent on a balanced utilization of farms and forests and (2) that of establishing a program for the "combination of work in mines with employment in forests or in adjacent local manufacturing plants or part-time farming." The first applies more especially to the Blue Ridge, the second to the plateaus.

A feature of the volume that recommends it to the attention of geographers is a remarkable series of some two hundred black-and-white maps in the text. These illustrate the distributions of an extremely wide variety of specific social and economic conditions and trends. In the chapter on education alone there are no fewer than 28 maps. Maps show the distribution of people, farms, doctors, dentists, parent-teacher organizations, churches, etc., how many divorces there are for 1000 marriages, what percentage of farms are lighted with electricity, and a host of other facts of interest. One might wish that the ingenuity expended on these maps had been carried a step further—that additional maps had been included bringing into juxtaposition certain critical facts now shown separately. Over a considerable part of the plateaus most of the countrypeople depend for their living on work in the mines rather than on farming. This means uncertain employment at best, and where the mines have been shut down there are "stranded communities," but not one of the maps gives a direct clue to their location. A map showing county by county the industries or groups of industries on which a majority or a plurality of the population are dependent would have told something in this connection and would not have been difficult to compile. As it is, the reader is forced to do his own synthesizing from a mass of discrete material in order to gain any concept of the combination of factors affecting any particular subregion of the Southern Appalachians. The volume, however, reflects credit on its authors for the care and skill that they have expended on describing and analyzing the data in their respective fields, and the maps provide an abundance of geographical source material.

The Poor Agricultural Whites of the South. The American South has always provided an attractive field of investigation for historians and in recent decades has become a fertile area for economic, geographical, and sociological research. Judgments on the South, however, especially in the past, have been so often clouded by sympathies and prejudices that a scholarly study by a foreigner, based on field work as well as on an intimate acquaintance with the available literature, must always be welcome to American students of this region. Such a work is Den Hollander's book on the poor-white farmers of the South (A. N. J. den Hollander: De landelijke arme blanken in het Zuiden der Vereenigde Staten: Een sociaal-historische en sociografische studie. J. B. Wolters, Groningen, etc., 1933). Although this study is primarily an economic history of a social class, much of the material contained in it is of great interest to the geographer.

The class of the poor agricultural whites as discussed by Den Hollander embraces considerably more than just the lowest stratum of Southern white society, the so-called "poor white trash." Before the Civil War more than two-thirds of the total number of white families in the cotton states did not have any direct property

interest in slaves. Most of these slaveless whites did not belong to the "poor white trash" but were small, independent farmers, who grew little or no cotton and who lived in a nearly closed agricultural economy. It is interesting to note, however, that most of these farmers were found outside the direct economic reach of the plantation districts of that time. Although their standard of living was low, they were proprietors and could not be considered as paupers. The real "poor white trash" lived mostly in the infertile sandy areas between the plantation districts, in the coniferous forests and the sand hills. The number of these *jager-boeren* (hunter-farmers), as Den Hollander calls them, has been variously estimated, and it cannot, of course, be determined from existing statistical data. The vagueness of the term "poor white trash" is undoubtedly partly the reason for divergence in estimate. Den Hollander is of the opinion that the causes of the unsatisfactory economic and social position of the nonslaveholding whites did not lie so much in the competition of the plantation as a large-scale agricultural enterprise and of cheap black labor as in the fact that in the economic system of the South land was a comparatively cheap item. Thus it was fairly easy for the planters to acquire all the good land within the cotton area. These statements, however, seem slightly inconsistent, since, after all, only the accumulation of profits, as a result of the large-scale capitalistic form of enterprise, made it possible for the planters to purchase the better land and gradually to push the small independent farmers out to the poorer soils.

After the Civil War the cotton area expanded rapidly, not only westward across the Mississippi but also into some of the pinelands and northward into the hills, and this ended the days of closed farm economy in these regions. Thus the class of the agricultural poor whites comes to embrace some small, semi-independent farmers and different gradations of white tenants, all primarily growing cotton. The picture Den Hollander draws of the living conditions of these poor rural whites is far from attractive. In Europe their counterpart can be found only in some of the backward districts of the southeastern part of the continent. One fact that forcibly strikes Den Hollander is the "un-Americanness" of the cotton system. Whereas elsewhere in the United States agriculture is mechanized to a considerable degree, in the South hand labor is still the principal economic factor. The bad system of agricultural credit comes in for much criticism, since it dooms the farmer to perpetual poverty. The American policy of extremely high industrial tariffs is also considered a great handicap to agriculture in general and to Southern agriculture in particular. The author sees a possible solution in the promotion of a system of small, independent farms for the white population and a more highly diversified type of agriculture. Here, however, he greatly underestimates the weight of the geographical factors.

A better geographical background would probably have aided the author in the presentation of his material. Maps, although they might have been very useful, are sadly lacking. The terminology is sometimes vague and not always free of ambiguity; the analysis of causal factors is weak in spots; and there are a number of inconsistencies in interpretation and conclusion. These faults, however, do not seriously impair the value of this study, which is the work of a competent and generally objective observer and student.

WILLIAM VAN ROYEN AND JAMES M. REINHARDT

Migration in Response to Changing Economic Conditions. It is generally accepted that, although population is fairly mobile, population density is imperfectly adjusted to the diverse economic opportunities existing in any considerable area at any time; that is, some regions support their populations at higher, others at lower, economic standards of living than regional differences in human ability warrant. A permanent correction of this condition would necessitate, essentially, that Aurousseau's population expansion ratios be made and kept the same everywhere (M. Aurousseau: The

Distribution of Population: A Constructive Problem, *Geogr. Rev.*, Vol. 11, 1921, pp. 563–592; reference on p. 566). Many obstacles confront those who would achieve such an undertaking; but there is a possibility that maladjustments of population to economic opportunity might be partially avoided or rendered less critical in certain areas if a sound national migration policy could be formulated and made operative.

A recent contribution by Goodrich, Allin, and Hayes (Carter Goodrich, B. W. Allin, and Marion Hayes: Migration and Planes of Living, 1920–1934, *Study of Population Redistribution, Bull. No. 2*, Wharton School of Finance and Commerce, University of Pennsylvania, 1935) throws considerable light on some of the problems involved. These authors have analyzed and roughly measured movements of population in response to changes in the distribution of economic opportunities in the United States between 1920 and 1934. Their contribution is of value because of the generalizations contained in it and because of its critical analysis of the validity of criteria of measurement as applied to numerous areas.

The authors use per capita income-tax returns, residence telephones, and radios in homes as measures of "planes of living" by counties in 1929. It is revealed that there is a reasonably close correspondence between the distribution of planes of living so measured and the distribution of such other items as gross agricultural income, retail sales per capita, various wage rates, and per capita income as estimated by Leven, Moulton, and Warburton (Maurice Leven, H. G. Moulton, and Clark Warburton: America's Capacity to Consume, *Publs. Brookings Instn., Inst. of Economics Ser. No. 56*, Washington, 1934). Relatively high planes of living were found to exist in the parts of the northeast quarter of the country where commerce and manufacturing are important, in much of the Corn Belt, and in some parts of the West, especially in California and Washington. Large areas with relatively low planes of living occurred throughout the South and in much of the Southwest. It is estimated that planes of living had about this same distribution between 1922 and 1929. Migration, as computed from the federal census and from available state school censuses, between 1920 and 1929 had two main trends: (1) from old to new agricultural areas and (2) from rural to urban areas. More persons were involved in the latter movement than in the former. On the whole, the rural areas with the lowest "planes of living" lost the most population, and the cities with the highest planes of living gained the most, though some relatively poor new lands of the West gained considerably in proportion to their populations of 1919. In the main, these shifts in population constituted a proper response to contrasting planes of living as plotted for 1929 and tended to bring about a condition of equilibrium among the population expansion ratios of the various parts of the United States.

Percentages of population receiving federal relief were used to measure economic distress for the year beginning July 1, 1933. It was found that the distribution of economic opportunities had changed between 1929 and 1933–1934 and that relatively abundant opportunities for making a living no longer prevailed in most urbanized areas. The highest percentages of persons on relief, however, were in the coal-mining districts of Pennsylvania and in West Virginia, eastern Kentucky, much of the South and Southwest, and the spring-wheat belt and the cutover lands of the upper Great Lakes region. Where available, school-census data were used to measure population shifts between 1929 and 1934. It was found that migration during the depression was to a considerable extent from the cities but toward the very areas that had the lowest planes of living in 1929 and the highest percentages of population on relief in 1933–1934.

The authors are fully aware of the shortcomings of their basic data and limitations of the findings are ably discussed. Maps by C. Warren Thornthwaite and Helen I. Slentz show the areal distribution of essential data.

ALLEN BELDEN

Stream **Terminology in Maryland.** Maryland streams are commonly known as *runs*, *creeks*, or *branches*. Examination of this terminology on the one-inch-to-a-mile maps of the Maryland Geological Survey shows a close relationship between topography and terminology (J. L. Kuethe: Runs, Creeks, and Branches in Maryland, *Amer. Speech*, Vol. 10, 1935, pp. 256–259). Of the runs, branches, and creeks of the state, the runs predominated to the extent of 79 per cent in the mountain area; branches to 43 per cent in the plateau; creeks to 67 per cent in the coastal plain. Three main elements seem to be involved in this nomenclature—the velocity and size of the streams and the early process of settlement, on the tidal waters of the Chesapeake. "It would seem that *run* is used in the mountains for the action, the speed, which it denotes; *branch* is used in the plateau because of the greater number of divisions or 'branches' in the streams of that section; and the term *creek* predominates in the coastal area because of the influence of the original meaning of the word, an inlet or tidal estuary."

The **Prairie Peninsula.** In the United States the problem of the prairie is in essence the problem of the prairie peninsula that extends eastward across Illinois into western Indiana with scattered outliers in southern Wisconsin, southwestern Michigan, Ohio, and western Kentucky. This eastward extension of the tall-grass prairie into the humid lands of interior America has perplexed explorers, geographers, and ecologists who have sought to interpret the distribution of the original cover of vegetation. E. N. Transeau, in a recent paper entitled "The Prairie Peninsula" (*Ecology*, Vol. 16, 1935, pp. 423–437), presents a detailed map of this grassland extension and a careful analysis of the problem.

His critical review includes an assemblage of observations and problems that will have to be settled before the origin, the development, and the maintenance of the prairie peninsula will have been explained to the satisfaction of all. It is observed that the southern limit of certain trees of the northern forest is roughly parallel to, though not coincident with, the northern border of the prairie. Near the eastern tip of the peninsula the deciduous forest invades the prairie on a variety of soil types and topographic features, but in Iowa the forest invasion is confined to the watercourses. The associations of the peninsular prairie are similar to those that Weaver and Fitzpatrick defined for the prairie center as represented in western Iowa, eastern Nebraska, and contiguous states to the north and south (J. E. Weaver and T. J. Fitzpatrick: The Prairie, *Ecological Monographs*, Vol. 4, 1934, pp. 109–295). These are only a few of the twenty-one observations that must be harmonized if an interpretation of the grassland peninsula is to be acceptable to the many students of the prairie.

Professor Transeau next presents sixteen numbered statements concerning the contributing factors that may, when properly analyzed and combined, yield the long-sought explanation of the prairie peninsula. The critical conditions include variability of precipitation, loss by evaporation, and the relative humidity of midsummer. There are also pedological and biological evidences that the prairie peninsula was once forested; but during a postglacial dry period the trees gave way to the grasses, and an eastward extension of the tall-grass prairie was established.

Probably the explanation of the prairie peninsula is to be found in the climatic conditions of the past, which were of critical significance in the development of the prairie, and in the climatic and ecological conditions of the present, which have combined to maintain a tall-grass prairie against the assaults of the bordering forest. The rainfall-evaporation data, first investigated by Transeau in 1905, suggest a hopeful approach to the problem (Forest Centers of Eastern America, *Amer. Naturalist*, Vol. 39, 1905, pp. 875–889). In so far as the explanation can be found in the climatic conditions of the present, some index of rainfall effectiveness must be sought in the statistical data on temperature, precipitation, evaporation, and relative humidity.

Such indices have been prepared by De Martonne, Lang, Thornthwaite, and others (see, for example, C. W. Thornthwaite: The Climates of North America According to a New Classification, *Geogr. Rev.*, Vol. 21, 1931, pp. 633–655). Thornthwaite's map of precipitation effectivity shows a sympathetic correspondence with Transeau's early studies of the same phenomenon and his recent map of the prairie peninsula. A close correlation may not follow from the suggested correspondence.

The variability of precipitation, particularly the critical rainfall of summer, should by a priori reasoning exert a profound influence on the distribution of the prairie flora. Unfortunately the maps of drought frequency are not entirely convincing (see National Resources Board: A Report on National Planning and Public Works . . . , December 1, 1934, Washington, 1934, p. 248). It remains, however, as a fundamental axiom of ecology that the extremes of climate are more critical than the averages. The recurrence of extreme droughts must be a critical desideratum in the competitive economies of the prairie and forest plants. Continued research in the fields of ecology and climate may yield eventually an acceptable explanation of the prairie peninsula.

GUY-HAROLD SMITH

SOUTH AMERICA

A Zone of Areism in South America. It has been observed by Emmanuel de Martonne, as one of the results of a study of the world-wide distribution of aridity, that a zone of areism, or zone where there is no appreciable surface runoff (Aréisme et indice d'aridité, *Comptes Rendus de l'Acad. des Sci. [de Paris]*, Vol. 182, 1926, pp. 1395–1398; Regions of Interior-Basin Drainage, *Geogr. Rev.*, Vol. 17, 1927, pp. 397–414), extends diagonally across South America from the Pacific to the Atlantic Ocean (La diagonale aréique de l'Amérique du Sud, *Comptes Rendus de l'Acad. des Sci. [de Paris]*, Vol. 198, 1934, pp. 592–594). The existence of this zone was first noted during a cartographic study and was later verified in the field. At latitude 20° S., that of Iquique, the highest crests still form a humid belt, but farther south, between the 24th and 29th parallels, the zone of areism traverses the Andean chain obliquely. The "index of aridity" was determined for a sufficient number of stations to give a series of east-west profiles revealing what might be called "surfaces of equal aridity." The surfaces descend from west to east in the northern part of the zone of areism and from east to west in the southern part, and they merge into one another near the axis of the range at about 30° S. A general explanation is to be found in the humid air currents coming from the east in the northern part and from the west in the southern. But the orography of the Andean system plays an important part. The mountain front, massive along the Argentine-Bolivian frontier, breaks down in the latitude where the dissymmetry in climate is reversed. South of latitude 26° S. the mountain system, composed of bolsons surrounded by mountains, is unfavorable to the formation of drainage systems without a constant water supply, and this it lacks. Furthermore, there have been in the recent past repeated tilting and downwarping of blocks, which would hinder the establishment of a good drainage pattern. These unfavorable conditions of orography in conjunction with the irregularity of precipitation are believed to account for the unique characteristics of this zone of areism.

In the Argentine plains to the east (Aréisme et mouvements du sol dans les plaines argentines, *Comptes Rendus de l'Acad. des Sci. [de Paris]*, Vol. 200, 1935, pp. 250–252) the slopes either are too gentle to allow runoff or perhaps descend to interior closed depressions. The plains in the southern part of the province of Buenos Aires, for example, receive at times heavy rainfall, but the slopes, with gradients of not more than 1 : 1000, are insufficient to allow water to move across the loess surface (an example of humid areism). The Argentine Chaco has very few streams, all of which come from the mountains, and the slopes are very gentle over a distance of

300–400 kilometers. The rivers, which enter the sub-Andean depression laden with debris, are unable to escape to the sea. Borings substantiate the belief that the depression is bounded on the west by a north-south fault. It is thought that downwarping of the sub-Andean depression counterbalances the accumulation of debris. It is also believed that we have in the Argentine plains one of the best examples of the effect of recent earth movements on the extent of areism.

The subject of aridity in South America is discussed more elaborately in a further article (Problèmes des régions arides sud-américaines, *Ann. de Géogr.*, Vol. 44, 1935, pp. 1–27; see also "The Andes of the North-West Argentine," *Geogr. Journ.*, Vol. 84, 1934, pp. 1–16), which contains a drainage map outlining the zone of areism and a map based on an index of aridity obtained from the ratio $P:(T+10)$, where P represents the precipitation in millimeters and T the temperature in degrees centigrade, 10 being added merely to avoid negative values (see "L'indice d'aridité," *Bull. Assn. de Géographes Français*, No. 9, May, 1926, pp. 3–5). More recent experimentation in formulas to indicate aridity has also considered, in one case, the number of days of rain and the mean for each station, and in another, probably more satisfactorily, a function of the latitude (Sur la formule de l'indice d'aridité, *Comptes Rendus de l'Acad. des Sci.*, Vol. 200, 1935, pp. 166–168). The best results seem to be obtained by combining the mean annual index with that of the most arid month.

In "Le milieu physique et les conditions anciennes du peuplement dans le nord-ouest argentin" (*Journ. Soc. des Américanistes*, N. S., Vol. 26, 1934, pp. 301–307) Professor de Martonne considers some of the human consequences of this peculiar distribution of the arid lands of South America.

EUROPE

The Exploitation and Colonization of High Peat Bogs in the Netherlands. Considerable portions of the Netherlands are occupied by peat deposits, which accumulated for the most part during the postglacial period and which might still be forming if man had not interfered. These deposits can be divided into two main types, the low peats (Dutch, *laagvenen*; German, *Niederungsmoore*) and the high, or moss, peats (Dutch, *hoogvenen*; German, *Hochmoore*). The two types differ in plant material and mode of formation, the high peat being primarily of supra-aquatic, the low peat of infra-aquatic, development.

Moss-peat deposits occur on the delta sands and glacial deposits of the eastern and southern parts of the Netherlands (see P. Tesch: Physiographic Regions of the Netherlands, *Geogr. Rev.*, Vol. 13, 1923, pp. 507–517) at altitudes ranging from 3 feet to more than 60 feet above sea level. In all these areas the natural landscape has been profoundly altered by human activities. Since the late Middle Ages man has been engaged in exploiting the peat resources and in transforming the underlying sandy mantle-rock into usable agricultural land. Thus there have developed in these regions a number of flourishing settlements, the so-called *veenkoloniën* (peat colonies), which all bear the stamp of their origin.

The largest of these moss-peat bogs was the old "Bourtanger Moor," which occupied nearly the entire area between the Ems River in Germany and the high sandy lands of the province of Drenthe. The genesis of this bog in southeastern Drenthe in its relationship to postglacial climatic development has been studied in detail (J. Visscher: Das Hochmoor von Südost-Drente geomorphologisch betrachtet, *Geogr. en Geol. Mededeelingen, Rijksuniv. te Utrecht, Physiogr.-geol. Reeks No. 5*, 1931).

Exploitation began first in the northwestern part of the Bourtanger Moor, in the province of Groningen, where some of the oldest *veenkoloniale* settlements are found. Here most of the peat has long since been replaced by a prosperous agriculture. The geography of this region has been treated exhaustively by H. J. Keuning (De Gron-

inger veenkoloniën: Een sociaal-geografische studie, Amsterdam, 1933). Although some peat was dug along the edges of the bog as early as the thirteenth century, large-scale, systematic exploitation did not start until the first years of the seventeenth century, when the city of Groningen had acquired extensive holdings in this area. Under the leadership of the city, and as a response to the great demand for *turf* occasioned by the lack of wood in the Netherlands and adjacent regions, exploitation proceeded steadily. Early in the nineteenth century practically all peat had disappeared in what are now the *Groninger veenkoloniën*, though to the south, in Drenthe, the exploitation of peat is still going on.

The first step in exploiting a peat area is to provide adequate drainage by constructing a main canal with laterals at distances of about 250 feet and still smaller ditches entering the laterals. After two to three years the peat is dry enough to permit actual digging. In this way a network of large and small canals developed, which not only facilitated the transportation of the *turf* but also became a great advantage in the later agricultural exploitation of the area, since practically all farms have access to navigable water. This network of canals still determines the aspect of the present cultural landscape. The farms were located along the main canals, the roads followed the canal banks, and the villages and towns that grew up in the area are all long and narrow, with the main business street on the *diep*.

After the peat is dug, the upper two feet of peat, which is of no value as fuel, is mixed with sand to form the future soil. In addition fertilizer is necessary, formerly compost and manure, now mostly artificial fertilizer. The extensive use of artificial fertilizer (eleven times the average for the Netherlands!) led to greater specialization in agriculture. The amount of grassland, and with it the number of cattle, decreased, and more and more the *Groninger veenkoloniën* began to grow potatoes, rye, and oats. In recent decades truck gardening, partly under glass, has become of considerable importance in the northwestern part of the region.

On the basis of the agriculture important industries have grown up. The potatoes are raised largely for the manufacture of potato starch, of which the Netherlands is the principal world producer and exporter. Although there are some private, or so-called speculative, factories, the bulk of the starch (85 per cent) is manufactured by farmers' coöperatives. The second important industry, the manufacture of strawboard, is based on the growing of rye in the *veenkoloniën* and of wheat on the marine clay lands to the north. More than 60 per cent of this industry is in the hands of coöperatives owned by farmers.

Although about one-third of the population are employed in agriculture, as a result of the presence of the starch, strawboard, and various other industries an equal percentage are engaged in manufacturing. Thus the region is well balanced. The truly "colonial" stage, when population increased rapidly, ended early in the nineteenth century. Since that time this region, which has a fairly high natural increase of population, has become an area of emigration, directed to the peat districts farther south and to other parts of the Netherlands.

WILLIAM VAN ROYEN

The Geography of Settlement in Spain. Throughout most of Spain, but more especially in the arid regions, the countrypeople live in compact villages. On the plateaus of La Mancha some of these villages are very large, "almost small towns . . . Between each grouping there are great expanses of level plain, perhaps ten or twenty miles wide, where buildings are few and far apart." Extensive areas of cultivated land are here associated with low densities of population. In the rainier northwestern provinces, where water is plentiful nearly everywhere, the situation is entirely different. "It is most inconvenient to move herds of cows long distances twice a day for milking, and in many regions such as this, where dairying is an essential part of farm life, the houses are found scattered among the pastures, not

agglomerated in villages." The distribution of types of rural settlement in Spain and some of the historical and geographical reasons for the differences in the several parts of that country are discussed in a short paper by H. Fairhurst (Types of Settlement in Spain, *Scottish Geogr. Mag.*, Vol. 51, 1935, pp. 283–296; see also note on "The Geography of Rural Settlements," *Geogr. Rev.*, Vol. 24, 1934, pp. 502–504).

The geography of settlement, both rural and urban, in the lowland of Andalusia, or basin of the Guadalquivir, is the subject of a recent comprehensive monograph by Georg Niemeier (Siedlungsgeographische Untersuchungen in Niederandalusien, *Hamburgische Univ., Abhandl. aus dem Gebiet der Auslandskunde*, Vol. 42, Ser. B, Vol. 22, 1935). Niemeier states that 38 of the 42 towns in the Andalusian lowland with a population of 8000 or more in 1920 occupy or are near the sites of Roman settlements and that 23 of these are on or close to the routes of Roman roads. All the historical and archeological evidence available tends to show that the region as a whole has been thickly settled since very early times. After the reconquest from the Moors population declined for several centuries, and large tracts that had previously been cultivated reverted to barren steppes, the limits of which Niemeier has been able to map. Since the eighteenth century these steppes have been reclaimed, and now there is little wasteland in the lowland, except for marshes near Cádiz. Recolonization was carried out in part by Germans, several thousand in number, introduced by Charles III in 1767–1768. Unlike the German settlers in Russia, Transylvania, and Brazil, who have clung to their speech and to many of their national customs, the Germans of Andalusia were rapidly Hispanicized. Today, however, one may read on lists of voters such names as Bäcker, Mitelbrun, Crestemayer, and even strange combinations like Mayer-Hernández and Hans y Hans.

Of the population of the Andalusian lowland 86.7 per cent live in cities, towns, and villages of more than 100 inhabitants each and the remainder in scattered habitations (*Streusiedlungen*). Niemeier subjects both types of settlement to detailed examination, analyzing and classifying them according to various characteristics, such as location, function, ground plan, and structure, and seeking rational explanations in terms of a balanced appraisal of historical and geographical factors. The ground plans, or street patterns, of the compact settlements are classified as lattice-shaped, feather-shaped, spear-shaped and umbelliform, irregularly radiating, net-shaped, Moorish-irregular, etc. Most of the existing ground plans are believed to date from the time of the reconquest; those of the older quarters of Seville, Córdoba, and certain other towns are Moorish; for only a few places does it seem likely that the plan has been preserved unchanged since Roman times, and in no case is this certain. If sometimes Niemeier's classifications seem to become a little abstruse—as in the case of "one, two, and three-dimensional towns"—the book by no means deals exclusively with matters of academic interest. It is full of illuminating firsthand observations concerning the surroundings amid which the people of the region lead their everyday lives. That Niemeier is far from blind to the human aspects of his subject could be illustrated by many quotations, of which one must suffice. Describing an extensive "Shantytown" on the outskirts of Seville, he says: "With grim humor the inhabitants call their settlement 'The United States' or 'Platinum City,' because not only pieces of cardboard and old boxes but tin cans have here been abundantly used as building material for some 2500 shanties."

Agrarian Reform in Spain. Pascual Carrión in a timely and well written volume (Los latifundios en España, Madrid, 1932) shows that *latifundios* or great estates are especially prevalent in the southern and western parts of Spain in the fertile, low-altitude valleys of the Guadalquivir and Guadiana rivers (see also Pierre Monbeig: La réforme agraire en Espagne, *Annales d'Hist. Écon. et Sociale*, Vol. 5, 1933, pp. 541–560). In these regions many of the best lands are in the hands of large landowners, whereas the poorer lands are in small parcels, much better cultivated, and owned

by small landholders. Latifundios exist irrespective of whether transportation facilities are good or bad; the large landowner prefers to buy more land rather than improve what he has. The latifundio is not a result of ignorance of efficient methods of farming or of the difference in character of the people of the west and south. The Andalusian is a good and intelligent worker on his own land, but as a wage earner on a latifundio he is proud and independent and perhaps more careless than workers from other regions. In Spain seven million people, one-third of the population, are directly concerned with this concentration of land in so few hands. Twelve thousand families own one-half of the land included in the cadastral survey, and the old belief that latifundios represent only agglomerations of poor land is untenable. The province of Alicante has almost twice the population to a square kilometer (96) as that of Seville (56), because Seville is to a great extent in latifundios. Irrigated land in Spain is almost entirely in those areas where small landowners prevail, especially in Alicante and Valencia. In Valencia the value of the yield of cultivated land averages 985 pesetas annually, whereas in the rich province of Seville the annual average is only 401 pesetas.

The great latifundios require few workers and then only at certain seasons. Pay is very low, and living conditions are bad. Whole regions are devoted to one-crop farming, and a too rainy or too dry season, a windstorm, or a bumper crop with a consequent sharp drop in prices may reduce the entire population to misery. Hence unemployment has long been chronic, and the people of this vast rural slum of Andalusia have for half a century been ready to follow any party—anarchosyndicalist or socialist—that has promised speedy and sweeping reform.

The consequences of the latifundios are depopulation of the countryside, inefficient methods of farming, low wages, high rents, scarcity of livestock, and a generally precarious economic situation for about a third of the country. Hence the Republican government is laying emphasis on intensifying the exploitation of the land and increasing the share of the peasant in the products thereby obtained. The worker, too, must become a farmer with land that he can cultivate intensively; diversified farming and dairying are to be fostered so that he will not be without work the greater part of the year.

Carrión estimates the total number of needy families at 680,000, and the available land at some 3,700,000 hectares. As 5,500,000 hectares are required to carry out the proposed agrarian reforms, it will probably be necessary to limit the size of latifundios to 250 hectares. The ultimate aim is an indefinite lease on a property with moderate rent for the farmer. To mortgage, sell, divide, or add to the property will be forbidden. It is hoped in this wise to eliminate abuses. The landholders concerned, only 25,000 in the entire country, will be paid off gradually in the course of a generation. In the end the present privileged classes will pay the bill in the form of taxes, but over a long period of time. In September, 1932, the Law of the Agrarian Reform, sponsored by the Republican regime, was promulgated and the Institute of the Agrarian Reform called into being to carry it out. This law defines the properties liable to expropriation. An elaborate system of payment for the expropriated estates has been worked out according to their size, kind of soil, improvements already made, etc. Agricultural instruction is encouraged; credit is to be extended for the purchase of modern equipment, selected seeds, and fertilizers; and coöperative societies will enjoy the benefits of crop insurance and information regarding when and where to sell their produce to best advantage. In addition to a discussion of the agrarian reform itself, E. Martinez de Bujanda in an article entitled "Agrarian Reform in Spain" (*Internatl. Rev. of Agric.*, Vol. 24, 1933, pp. E 113–130) gives a résumé of the agricultural regions of the country.

In the present writer's opinion there must be at all times a ready flow of credit to assist competent peasants, be they renters or petty landowners, and they must not relax in organization for the defense of their interests against large landowners and

ex-landowners. Even supposedly dispossessed landlords can make life very disagreeable for peasants who have been granted plots on what were formerly their estates—as was only too often the case in Mexico. All other problems in Spain fade into insignificance beside this one of agrarian reform. According as it is or is not satisfactorily solved, millions of people either will achieve a standard of living to which human beings are justified in aspiring or will continue to vegetate in illiteracy, misery, and squalor.

RAYMOND E. CRIST

"Baltic Countries." The Baltic Institute, with headquarters in Toruń, Poland, presents an impressive new journal that is intended to incorporate "a survey of the peoples and states on the Baltic with special regard to their history, geography, and economics." It is the Institute's belief that, with some fifteen million nationals from the countries of the Baltic region now in the United States and Canada, besides those in other parts of the world, the English-speaking peoples should be fully informed regarding the cultural life of the home countries. The countries included within the scope of this journal are Poland, the new Baltic States, Finland, Sweden, and Denmark. Norway will be dealt with upon occasion.

Baltic Countries is divided into four parts: (1) history, geography, and economics of the Baltic region; (2) a discussion of the scientific institutions of the Baltic and cultural relations with the rest of the world; (3) reviews of books dealing with the Baltic and its parts; and (4) a bibliography of literature bearing on the same region. In addition, there is a statistical supplement incorporating data for a *Baltic Yearbook*. Germany is included in the *Yearbook*, but the U. S. S. R. is omitted because "of its unusual and complicated structure." On the other hand, Germany is not to be considered in the discussions in the body of the journal.

Although all the articles, as the objective of the journal indicates, are not geographical, a number of them are clearly or partially so. A few suggestive titles follow: "Climate and Population," "Coastal Barriers of the Baltic," "Demographic Survey of Estonia," "Geographical Society of Finland."

The article treating of "Coastal Barriers of the Baltic" contains an interesting philosophy regarding the relationship between countries bordering seas and those sovereign states that they separate from the sea. In this sense, for example, Finland, Estonia, Latvia, and Lithuania are coastal barriers to the U. S. S. R. "The pressure of the inland States upon the coastal barriers is permanent, and in the light of history appears . . . to be gaining in force." "The possibility . . . of friction arising through the existence of coastal barriers is always present, and . . . for this reason the present status of the Baltic coastal barriers cannot be accepted as final."

Many of the articles are illustrated with graphs, diagrams, and tables. The list of contributors includes outstanding men associated with universities, scientific institutions, and government bureaus of the various countries. The Editorial Committee is representative not only of Baltic countries but of other nations. Publication for the first year will include three numbers. If the future numbers meet the high standard of the first one, a successful career for *Baltic Countries* is assured.

EUGENE VAN CLEEF

POLAR REGIONS

Lincoln Ellsworth's Flight Across West Antarctica. By his recent remarkable flight of 2200 miles from the tip of the Graham Land archipelago to Little America Lincoln Ellsworth has reversed the usual sequence of Antarctic exploration, which begins with an outlining of the coastal belt, and has revealed the chief topographical features of a wide strip in the interior of West Antarctica before any of its coastal outline except two relatively short stretches is definitely known.

The main flight of discovery was preceded by two attempts, from both of which return had to be made to Dundee Island, the starting point. On November 20, 1935, the flight progressed only to 65½° S. beyond Robertson Island; on November 21 the threshold of the unknown was reached by an advance to 71½° S. beyond Stefansson Strait (details of all three flights are given in the *New York Times*, November 22, 24, and 26, 1935, and January 18, 19, 22, and 23, 1936).

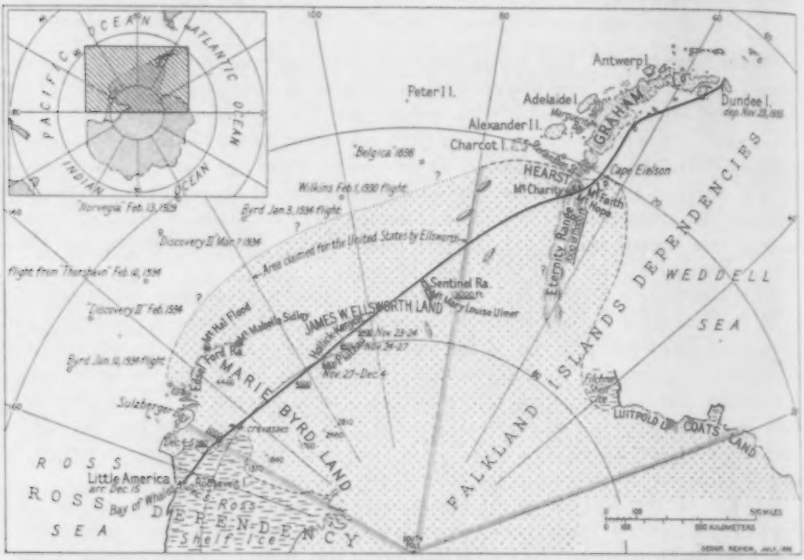


FIG. 1—Preliminary sketch map of Ellsworth's flight across West Antarctica, Nov. 23–Dec. 5, 1935, based on the newspaper dispatches cited in the text. Scale 1 : 38,000,000. The topographical features along the flight route are necessarily approximate only, pending the definitive publication of the expedition results. Elevations not underscored are derived from the second Byrd Antarctic expedition. The ship and flight positions offshore represent the southernmost advances so far made in this sector.

The flight that was to achieve the goal started on November 23, 1935, and ended on December 5 within a few miles of Little America. It was carried out in Mr. Ellsworth's Northrop monoplane *Polar Star* with himself as navigator and Herbert Hollick-Kenyon as pilot. Four intermediate landings were made, the two men successfully camping on the ice and securing the airplane for periods of a few hours to a week. At the threshold of the unknown, the passage of Stefansson Strait confirmed the earlier observation that the actual strait is much narrower than it is represented on Sir Hubert Wilkins' reconnaissance map (*Geogr. Rev.*, Vol. 19, 1929, Pl. IV)—only about one mile wide—and that the Finley Islands lie closer together. The depression in which the strait and islands lie is, however, of large proportions, as that map implies. That this is a transverse depression running across the Graham Land mountain axis was confirmed by the next—the chief—discovery of the expedition.

South of Stefansson Strait began a mountain range trending northwest-southeast that in appearance and arcuate alignment continued the axis of the mountains of Graham Land. The range, named Eternity Range by Mr. Ellsworth, was about 100 miles wide and rose to elevations of 7000 to 12,000 feet; three prominent peaks at the north end were designated Mt. Hope, Mt. Faith, and Mt. Charity. The spacing of the constituent massifs of the range was relatively open, and valley glaciers were lacking.

Although there seems a reasonable probability that this range represents the con-

tinuation of the Antarctandes, the main problem of their structural relation to the rest of the continental mass remains an open question. The new discoveries hint at the existence of three axes diverging fanwise to the south: (1) the Graham Land–Eternity Range axis; (2) a minor intermediate axis defined by the islands west of Stefansson Strait sighted by Wilkins on his flight of December 29, 1929 (*Geogr. Rev.*, Vol. 20, 1930, p. 374), and by a second range that he places on the mainland in 73° 30′ S. and 74° W. in his analysis of Ellsworth's flight of November 23 (*New York Times*, November 26, 1935); and (3) the axis of the western offshore islands of Graham Land, Antwerp, Adelaide, Alexander I, and Charcot. The existence of such a virgation at what would be the extreme end of this world tectonic lineament has been forecast by the Swiss geologist Staub (Rudolf Staub: Der Bewegungsmechanismus der Erde, Berlin, 1928, pp. 117–118 and map in pocket).

Beyond the west slope of the range, which was characterized by nunataks decreasing in elevation and number, lay a great ice-covered plateau about 6000–7000 feet high from which isolated massifs protruded at intervals to about the 90th meridian along the line of flight, two of them possibly near 75° W. and 76° S. and 90° W. and 79° S., the latter being the last mountains observed. At a location working out approximately to 88° W. between 77° and 78° S. rose a solitary range about 75 miles long, symmetrically formed, whose peaks reached 13,000 feet and were clustered into a central mass. The range was named Sentinel Range; the central peak, Mount Mary Louise Ulmer, for Mr. Ellsworth's wife.

From about the 90th meridian to about the 115th meridian along the line of flight the high, level ice-covered plateau continued without interruption. Landings were made in this stretch and elevations determined at the following points: 79° 12′ S. and 104° 10′ W., 6400 feet; 79° 30′ S. and 107° 55′ W., 6400 feet; 79° 58′ S. and 114° 15′ W., 6300 feet. At the first landing the United States flag was raised in accordance with permission obtained from the Department of State, and the area between Hearst Land and Marie Byrd Land, i.e. between the 80th and 120th meridians, was claimed for the United States. This area was named James W. Ellsworth Land after Mr. Ellsworth's father, and the plateau above 6000 feet Hollick-Kenyon Plateau. At about the 115th meridian along the line of flight the plateau began to descend, decreasing to estimated elevations of 4500 feet at about the 125th meridian and (after a steeper gradient marked by crevassing at the 145th meridian) of 1000 feet at the 150th meridian and to a measured elevation of 980 feet at the landing on December 4 in 79° 17′ S. and 153° 16′ W., a point 150 miles east-southeast of Little America. The 980-foot elevation provides an additional datum to refine the border of the inland ice toward the Ross Shelf Ice as outlined particularly by the work of the tractor party of the Second Byrd Antarctic Expedition, and the crevasses fit in well with that delineation (end-paper map in R. E. Byrd: Discovery: The Story of the Second Byrd Antarctic Expedition, New York, 1935).

On December 5 the flight was continued toward Little America, but the final landing had to be made 15 miles short of the goal, in 78° 45′ S. and 163° 36′ W., because the fuel had given out. After a halt of four days the rest of the journey was completed on foot, and, after a detour that led them to the outer edge of the shelf ice northeast of the Bay of Whales, Ellsworth and Hollick-Kenyon reached Little America on December 15. Here they stayed in one of the huts of the Byrd expedition until they were sighted on January 15 by an airplane flown from the research ship *Discovery II* of the Discovery Committee of the British Colonial Office, which had proceeded to the Bay of Whales at the behest of the British, Australian, and New Zealand governments to search for the explorers, inasmuch as they had not been heard from since eight hours after their departure, when their radio failed in 79° W.

Ellsworth's own vessel, the *Wyatt Earp*, with Sir Hubert Wilkins on board, had in the meantime undertaken the relief voyage, whose details had been carefully planned before the flight. Leaving Dundee Island on November 27, the vessel proceeded via

Deception Island to Magallanes, Chile, where an airplane was put on board that had been flown in six days from Kansas City, and then steamed for Charcot Island to lay a prearranged depot. Poor weather and lack of smooth ice for a take-off prevented this, and the vessel proceeded westward along the pack-ice border toward Little America. The *Wyatt Earp* arrived at the Bay of Whales on January 20, five days after the *Discovery II*.

Use of Plankton in the Prognostication of Ice. Observations made aboard the *Lütke* on its Arctic voyage in 1934 (see "The Northeastern Passage of the Icebreaker 'Lütke,'" *Geogr. Rev.*, Vol. 25, 1935, pp. 339–340) showed the existence of a well defined relationship between the amount of plankton and the distribution of ice, ocean currents, and other hydrological elements. An interesting phenomenon observed in the Chukchee Sea is reported by V. G. Bogorov, hydrologist on the *Lütke* (*Meteorological Messenger* [in Russian], Vol. 45, 1935, p. 57). As the edge of the ice field was approached—for a distance of about 30 miles—the amount of plankton sharply increased, but in the compact ice field itself there was much less than in the open sea. This is explained by the fact that at one and the same time different parts of the ocean are experiencing biological winter, spring, or summer. The absence of sunlight and other conditions creates a winter plankton under the ice; in the region about the edge of the ice field there is observed a "spring coloring," an enormous amount of plankton; and in those parts in which the surface has been long free of ice there is less plankton—a characteristic summer condition. The qualitative make-up of the plankton shows a similar relationship. Under the ice only animal organisms are found; near the edge there is an enormous development of all organisms that require sunlight; in the region of the summer plankton the characteristic make-up is that of animals and sea plants combined.

This phenomenon was observed a number of times during the course of the expedition, and from the sharp increase in the amount of plankton it was possible to forecast the presence of the ice field ahead of the ship.

I. I. SCHELL

PHYSICAL GEOGRAPHY

Depths in Small Bays in Relation to Prevailing Winds. In a series of three papers under the title "An Investigation on the Effect of Prevailing Winds upon the Depth of Bays" (*Geophys. Mag.*, Vol. 9, Tokyo, 1935, pp. 105–174) M. Nakano studies the distribution of depths in small bays in relation to local prevailing winds. That strong winds must affect the depths within such bays is evident from general considerations. A wind blowing on or off a coast gives rise to a vertical circulation of the water; hence in relatively shallow bays movement of the bottom material must arise as a result of strong winds.

In the first paper Nakano develops a simple formula for the relation of location along the shore of a bay to the vertical-circulation effect of the prevailing wind. This formulation permits the construction for any given bay of a curve that may be called the wind-effect curve. From a chart of the bay the depths along equally spaced belts parallel to the shore of the bay are then determined. The depths along the central line of each of these belts may then be plotted as a curve on the same base as the wind-effect curve.

If the distribution of depths in a bay is related to the prevailing wind, we should expect a parallelism between the depth curves and the wind-effect curve. In the first paper Nakano applies the above procedure to Suttsu Bay, a small bay on the coast of the Japan Sea. This is particularly well suited for the study; for the tidal currents here are weak, and no large river enters into the bay to complicate matters. Comparison of the wind-effect and depth curves for this bay shows that on the whole there is a marked parallelism even with regard to minor fluctuations in the curves.

As the depths in a bay are affected to some extent by the general topographic features of the shore, an exact parallelism between the two sets of curves cannot be expected. But it is noteworthy that where there are discrepancies they can generally be related to the topographic features. It is to be noted, too, that the parallelism is closest in the shallower parts of the bay. This leads to the conclusion that the effect of prevailing winds on the distribution of depths extends only to the depth at which material on the bottom can be stirred up by waves. And, as the author notes, this provides a means for determining roughly the depths within which material on the bottom of a given bay is affected by waves.

In Suttsu Bay the prevailing wind is from the coast and perpendicular to the mouth of the bay. In his second paper Nakano investigates a case in which the wind is in the contrary direction, that is from the sea directly into the bay. This condition he finds to exist in Hakodate Bay. Comparison of the wind-effect and depth curves for this bay also shows a parallelism between the curves. The topographic features of the shore of this bay are not so simple as those of the shore of Suttsu Bay; hence the parallelism is not so close. Nakano therefore studies the topographic effects with a view to eliminating them.

In the third paper the author considers the case of a bay into which rivers discharge. The example chosen is Mano Bay, into which two rivers empty. The relation between the wind-effect and depth curves for this bay shows relatively large deviations from parallelism for certain parts of the bay, as is to be expected. From these investigations it appears that prevailing winds exert a definite influence on the distribution of depths in small and relatively shallow bays and that, where other agents, such as tidal or river currents, are of only minor importance, the distribution of depths will be in accordance with the effect of prevailing winds.

H. A. MARMER

HUMAN GEOGRAPHY

Trade Boundaries Determined by Traffic Flow. The limits of an urban trade area have commonly been defined by the distribution of residential, or fixed, population, and the area itself has sometimes been utilized as an index for delineating the limits of a metropolitan city. In the belief that a market is determined by the activities of a people rather than by their fixed positions, two traffic engineers have tried to solve the problem "of determining the boundaries of markets and the functional parts of markets" through a study of daily population movements in retail trade (John Paver and Miller McClintock: Traffic and Trade, New York and London, 1935). Their investigations were concerned with not "where people live but where and how they go to buy." They studied traffic flow, including pedestrian, automobile, and truck traffic, to fix the limits of what geographers sometimes think of as the "umland" and the immediate urban hinterland.

The figures for total flow of various types of traffic for the period 6.00 a. m. to midnight for specified points were plotted upon a base map and also upon coördinates. Two curves were established, one showing the "traffic divide," or low point of traffic flow between a trade center and its nearest important competitor—namely between the urban markets of Indianapolis and Terre Haute—and the other showing the low point in population density between the same two centers. In the first curve the point of traffic stabilization was found where the "rapid rate of declining volume" of traffic from the market center "changes to a lower rate of decline." In the second curve the point of traffic stabilization was found to coincide approximately with the decrease in population density occurring at the outskirts of the urban market. Thus the investigators conclude that the point of traffic stabilization may be used to define the limit of the urban market. The traffic divide determines the boundary of the primary retail trading area, i.e. the immediate hinterland, or the trade area beyond the urban market or umland.

The authors arrive at certain conclusions of interest to the urban geographer. (1) "The space distribution of total traffic forms stable patterns that indicate the daily habitual movement of population." (2) "The time distribution of various classes of traffic creates characteristic and normal patterns resulting from fundamental and stable community habits." (3) "The functions of retail trade are closely related to the daily movement of buying power in terms of traffic flow." (4) "Standard traffic-flow maps or space-distribution patterns of daily buying-power mobility can be used as effective guides in establishing the boundaries of basic urban markets and primary retail trading areas."

Methods are presented for deriving multiplying constants for use in connection with short-period counts for calculating 12, 18, and 24-hour totals. Also, standard linear base-map scales are given for plotting the urban markets for cities with given population numbers and another set of scales for plotting the primary retail trading areas. Likewise, desirable scales for drawing traffic bands are given. Numerous maps and graphs illuminate Paver and McClintock's stimulating work.

EUGENE VAN CLEEF

Recent Developments in the Vegetable-Oil Industries. Tung oil, "the best drying and waterproofing oil of vegetable origin known to technical science," has been imported into the United States in recent years in such quantities as to stimulate an interest in the development of the industry in this country. A newspaper item reports a shipment of 2,700 gallons—said to be the largest made in this country—from the Mississippi-Louisiana producing area (*New York Times*, October 13, 1935). As the trees from which tung oil is derived (*Aleurites*) are sub-tropical and can not withstand extended periods of cold the development is limited to the southern United States. Results have shown that the area of successful cultivation of *Aleurites fordii* will probably be restricted to a rather narrow strip—100 miles wide or less—in southern Alabama, Mississippi, Louisiana, the northern one-third or one-half of Florida, the southern and southeastern section of Georgia, the Gulf country of Texas. A minimum annual rainfall of thirty inches is essential, and the best results are obtained where it is over forty inches. The western limit is apparently in Texas at about the ninetieth meridian; west of that the rainfall is too irregular and insufficient. Within these areas the soil and drainage requirements will largely determine the regions for development. Soil uniformity (slightly acid soil seems to give the best results) over large areas is desirable in commercial planting (C. C. Concannon: Tung Oil, *U. S. Bur. of Foreign and Domestic Commerce Trade Promotion Ser. No. 133*, 1932).

China produces by far the greatest part of the world's supply of tung oil but there is a widespread and growing interest in the industry in many countries throughout the world. Satisfactory results have been obtained in a number of experimental plantings (J. Legros: Cultivation of *Aleurites*, Wood-Oil Trees, *Internatl. Rev. of Agric.*, Vol. 26, 1935, pp. 129T–160T, 183T–197T, and 237T–251T). In Japan the wood-oil trees (*Aleurites cordata*) are generally grown on the slopes of hills and of necessity are cultivated on poorer ground, since the most suitable areas are already utilized for other crops. Eighty per cent of the harvest comes from Fukui—almost entirely from the coastal area along the Japan Sea. Contiguous to Fukui are Ishikawa and Kyoto, also producing areas, and farther to the west but still on the border of the Japan Sea is the producing area of Shimane (Jean Motte: *L'Aleurites cordata* au Japon, *L'Agronomie Coloniale*, Vol. 24, 1935, No. 210, pp. 183–193; No. 211, pp. 7–15; and No. 212, pp. 45–55).

Safflower, also used for the production of a drying oil, has been suggested as a possible new oilseed crop that could be raised on the northern Great Plains on dry land or under irrigation. It "fits well into the agriculture of the northern Great Plains and requires no change in either methods or machinery now in use for production of

small grains." It also seems well adapted to winter dry-land farming in certain sections of the Far West. Safflower has been cultivated in Egypt and India for many years as an oilseed crop and as a source of a red dye obtained from the flowers (Frank Rabak: Safflower . . . . , *U. S. Dept. of Agric. Circular No. 366*, 1935).

"India abounds in a number of kinds of oil-seeds of which the most important are groundnut . . . seasamum . . . rape and mustard . . . and linseed . . . A considerable quantity of the large production of oil-seeds is exported, and it is of interest to trace the fluctuation of this export trade in recent years. As a result of the Ottawa Trade Agreement, Indian vegetable oils and seeds enjoy important tariff preferences in the United Kingdom, and by the same agreement certain tariff preferences on Indian vegetable oils were secured in other parts of the British Commonwealth. The consequences of this preferential treatment of Indian oil-seeds is clearly brought out by a comparison of the export figures of 1933–34 with those of former years. The total exports of Indian oil-seeds of all kinds improved in quantity from 733,000 tons in 1932–33 to 1,124,000 tons in 1933–34." Groundnut is the most important of the Indian oil-seeds from the point of view of acreage, total production, and export (F. J. F. Shaw: Indian Oil-Seeds, *Journ. Royal Soc. of Arts*, Vol. 83, 1934–1935, pp. 945–968). The results of an exhaustive survey made by the Intelligence Branch of the Imperial Economic Committee of groundnut production particularly in the British Empire are published as the third volume of a "Survey of Oilseeds and Vegetable Oils" ("Ground Nut Products: A Summary of Production and Trade in British Empire and Foreign Countries," London, 1934). Earlier volumes dealt with "Oil Palm Products," in 1932, and "Coconut Palm Products," 1932. The first issue of a new series of "Malayan Planting Manuals" deals with the "Oil Palm in Malaya" (B. Bunting, C. D. V. Georgi, and J. N. Milsum, Kuala Lumpur, 1934).

In the Philippine Islands more Filipinos are dependent on the production of copra than upon any other Philippine industry. In recent years one-third of the world's export trade in copra and coconut oil has been supplied by the Philippines. Nearly all of the oil and from two-thirds to three-quarters of the copra are exported to the United States. At present copra is admitted to the United States free of duty. In all probability the industry will be affected by the Philippine Independence Act and the United States processing tax (L. P. Rice: Philippine Copra and Coconut Oil in the American Market, *Far Eastern Survey*, Vol. 4, 1935, pp. 156–161).

Another industry which has had a long and hard struggle to establish itself is the vegetable-shortening industry. The economic history of this important industry in America is outlined by G. M. Weber and C. L. Alsberg in "The American Vegetable-Shortening Industry: Its Origin and Development" (*Fats and Oils Studies No. 5*, Food Research Institute, Stanford University, Cal., 1934). The authors conclude that "the future is obscured by too many politico-economic unknowns." For a general survey of conditions in the industry "Present Day Tendencies of Production and Consumption of Margarine" (H. Böker, *Internatl. Rev. of Agric.*, Vol. 25, 1934, pp. 517E–541E) may be consulted.

METHODOLOGY AND EDUCATIONAL GEOGRAPHY

Geography, the Correlative Science. The University of Toronto deserves congratulations on its new chair of geography and its holder, Griffith Taylor, whose inaugural address, "Geography the Correlative Science," is published in the *Canadian Journal of Economics and Political Science* (Vol. 1, 1935, pp. 535–550).

One of Professor Taylor's special gifts is that of expressing conclusions in diagrams that can be very stimulating to thought. With characteristic bold suggestiveness he works out an application of Willis' "Age and Area" hypothesis to questions of race and language, aiming at showing in this way the contribution of geographical

thought to studies in other fields. If a succession of novelties spreads from a center, then, on the analogy of waves started by dropping a stone in a pond, the oldest of these features will be found outermost. It is a valuable idea but one to be used with caution. Do all the new features start from a common center? May not new features arise among types toward the—hypothesized—periphery? The diagram of Chicago's growth, shown by four-tiered perspective maps (Fig. 4), is interesting; of course the center is the oldest part, but it is there that the latest novelties develop. Naturally suburbia has its own adaptations too. The trouble about such diagrams, even by so skilled a hand as that of Professor Taylor, arises from the fact that they may suggest things the author did not intend. Did the hollow-horned ruminants spread in three waves (Fig. 3), namely antelopes, cattle, sheep? Are we justified in thinking of four southward race waves from a common center in inner Eurasia to be named Negro (with Negrito), Australoid, Mediterranean, Alpine? We may use W. D. Matthew's guess that *Homo* has an Asiatic cradle, but does this apply to *Homo sapiens?* The earliest skeletons of *H. sapiens* so far known are Aurignacian, i.e. belonging to the later Pleistocene, but they are obviously not the beginning of our race. Trying to estimate the likelihood of the relationship of earlier cultures to *H. sapiens*, many are inclined to argue that the Acheulean and the contact-culture forms of the Mousterian arising where Acheulean and proto-Mousterian met are the likeliest to have been connected with the early stages of our ancestry. If the Acheulean turns out to be the one most concerned, its distribution suggests an origin in the belt of North Africa and southwestern Asia that has since become much more arid. On the other hand, the "Alpine" groups have their birth zone along the mountain folds of western Asia, with extensions into Europe and eastern Asia. Thus in this case we are not dealing with successive spreads from a common center.

Similar caution is needed in interpreting the diagram of the spread of European languages (Fig. 5); otherwise one might easily fall into the old and probably erroneous view that Slavonic languages spread into Russia from the east, whereas many believe that they took shape on the loess of the Carpathian region and radiated thence eastward as well as westward.

A remarkable "Time-space Diagram" of the chief expansions of European peoples will repay some examination, and one hopes that its author will go on elaborating it. Perhaps at Toronto he might convert it into a three-dimensioned diagram with a series of horizontal glass plates over one another. Even in these tentative diagrams the Byzantine Empire has its importance in the life of Europe brought out in a dramatic way—a useful correction of the widespread tendency to look on European history as centering round rivalries of Empire and Papacy. The Roman province of Europe is after all only a part of the continent, a little too inclined in the past to be obsessed by its own importance.

Professor Taylor has distinguished himself in special studies, notably in Australia, and has shown courage in developing applications of scientific conclusions to public problems, but beyond all this he sees the need for bringing specialisms together through this contact with Mother Earth, and he is evidently going to work along this line in Toronto as of old.

H. J. FLEURE

Land-Form Regions of Australia. In his presidential address, "The Content of Geographical Study," before Section P (Geography and Oceanography) of the Melbourne meeting of the Australian and New Zealand Association for the Advancement of Science in 1935 (*Report*, pp. 401–433) Professor J. Macdonald Holmes reminds his audience that geography has a scale of values, or a philosophy, as well as a factual content and that this scale of values derives from its unity. "Unity in all geographical study comes from its chief function, namely, measurement of major earth phenomena so as to evaluate the forces moulding the earth's surface as a whole.

and this applies to any phenomenon, whether landscape, climate, or population." By way of illustrating his thesis he offers a classification of the landform regions of Australia. "The essential geographical unity here is to visualize the combination of several factors operating together over an area to produce a regional landscape as an entity, and further, an entity which has not only a history but a future." The classification is done on a descriptive basis—until Australia is adequately mapped, quantitative measurement is not possible. The units are tabulated by groups, the members being allied in the sense of giving "a picture of the distribution of a similar type of surface," and shown on a map, "a first approximation on a physiognomic basis."

Polyglot Dictionaries of Technical Terms. During the last few years an unusual number of technical polyglot dictionaries have been published. The Hoyer-Kreuter "Technologisches Wörterbuch" (6th edit., 3 vols., Berlin, 1932) is a comprehensive work in French, German, and English. Industrial, technical, mining, commercial, and agricultural terms are included.

An oceanographical vocabulary in which about six hundred terms are listed in parallel columns with no attempt at definition but with equivalents in Latin, Italian, French, English, and German is the "Vocabulorum Elenchus Prior: Lexico Totius Scientiae Oceanographicae Redigendo" (*Bibliographia Oceanographica*, Venice, 1935). In 1932 the International Hydrographic Bureau published a "Vocabulary Concerning Tides" (*Special Publ. No. 28*), whose object was "collecting in a few pages the essential terms employed for the description and calculation of Tides." The most important current expressions were given in English and French. Two years later this was followed by a list with equivalents in German, Dutch, and Spanish (*Special Publ. No. 28a*), and the Bureau intends to undertake the publication of the vocabulary in other languages. The Bureau has also published "Terminology of Submarine Relief" (*Special Publ. No. 22c*, 1932), which gives equivalent terms in tabular form, and "Vocabulary Concerning Fog Signals" (*Special Publ. No. 29*, 1933), in which the French and English equivalents are given.

A "Composite List of Terms Relating to Ice, Which Appear in the Various Sailing Directions," giving the French, English, and Russian equivalents, was published in "Ice Terminology" by H. Bencker (*Hydrogr. Rev.*, Vol. 8, 1931, pp. 114–131).

The Permanent International Association of Navigation Congresses has undertaken an "Illustrated Technical Dictionary" in French, German, English, Spanish, Italian, and Dutch. The work is to be divided into chapters, each chapter to be published as soon as it is ready. Chapter 10, "River Weirs," is completed. The geographer will be particularly interested in the first three chapters, which are to deal with "Water and the Sea," "Streams, Rivers, Canals," and "Coasts and Shores." Drawings illustrate each term.

The Deutsche Gesellschaft für Photogrammetrie has produced a useful handbook in its "Mehrsprachiges Wörterbuch für Photogrammetrie: deutsch, englisch, französisch, italienisch, spanisch" (1934), in which 1850 terms are listed. No definitions are given, but the usefulness of the work, which is alphabetized under the German term, is increased by the English, French, Italian, and Spanish indexes.

The International Federation for Housing and Town Planning has published an "International Glossary of Technical Terms Used in Housing and Town Planning" (*Special Rept. No. 2*) with English, French, German, and Italian equivalents. All the terms are in alphabetical order "in a single list, with their equivalents side by side."

Under the aegis of the State Agricultural College at Wageningen there has appeared the "Dictionary of Terms Relating to Agriculture, Horticulture, Forestry, Cattle Breeding, Dairy Industry, and Apiculture" compiled by T. J. Bezemer. This is not a descriptive or defining dictionary. It is divided into four sections: English, French, German, and Dutch.

"Geologische Nomenclator" (The Hague, 1929) presents in parallel columns Dutch, German, English, and French geological terms. The work is divided into sections, each compiled by a different person, and there are four indexes listing the terms in each of the languages included. There are several other geological dictionaries that might be noted here, though they do not come within the polyglot category. Stanislas Meunier's "Dictionnaire de Géologie" (Paris, 1926) gives definitions in French, and many of them are long, illustrated, almost encyclopedic discussions. G. M. Davies' "A French-English Vocabulary in Geology and Physical Geography" (London, 1932) gives English equivalents but not definitions. There is a surprising difference in the terms included in these two works. C. W. Schmidt's "Wörterbuch der Geologie, Mineralogie und Paläontologie" (Berlin, 1928) is an enlarged edition of his earlier "Geologisch-mineralogisches Wörterbuch" (1921), which was published as a companion volume to Kende's "Geographisches Wörterbuch" (see *Geogr. Rev.*, Vol. 20, 1930, pp. 175–176). The "German-English Geological Terminology" by Arnold Cissarz and W. R. Jones (London, 1931) is presented as a running series of definitions by subjects, with English on one page and German on the opposite, and with German and English indexes. Another useful dictionary giving German and English terms is "Volkswirtschaftliches Wörterbuch" by H. T. Price (2 vols., Berlin, 1926–1929).

GEOGRAPHICAL NEWS

Presentation of the Henry Grier Bryant Gold Medal to President Isaiah Bowman. On December 12, 1935, the Henry Grier Bryant Gold Medal of the Geographical Society of Philadelphia was presented to President Isaiah Bowman of the Johns Hopkins University. The medal, which is awarded "For Distinguished Services to Geography," was established in memory of the late Mr. Henry G. Bryant, and Dr. Bowman is the first recipient (*Bull. Geogr. Soc. of Philadelphia*, Vol. 34, 1936, pp. 24–25).

OBITUARY

Count David Costantini. Count David Costantini, scientist and diplomat, died in Monte Carlo on January 10, 1936. As a scientist Count Costantini was interested primarily in paleogeography. In his address "Studies and Researches on Prehistoric Man and His Origins" before the 1928 meeting of the International Geographical Congress he made an earnest plea for a study of physical conditions, expressed in map form, as a basis for the investigation of man's prehistoric past, a plea that led to the formation of the Commission for the Preparation of Palaeogeographical Maps, of which he was appointed president. In this address Count Costantini stressed the need of international coöperation. "I desire to stress the fact that nowadays, if we wish to give new momentum to the progress of our studies, we must feel that, having reached a great turning-point in the furtherance of our knowledge, we may call upon the organized resources of all men to unite in purpose and in action."

It was in furtherance of this idea of coöperative effort that Count Costantini provided the American Geographical Society with the initial support for a study of marine terraces to be made in coöperation with the Carnegie Institution and Columbia University (see *Geogr. Rev.*, Vol. 21, 1931, p. 313; Vol. 22, 1932, p. 308). A summary of the first results was given by Douglas Johnson, in charge of the project, in "Principles of Marine Level Correlation" (*Geogr. Rev.*, Vol. 22, 1932, pp. 294–298), and a fuller statement was presented by him before the 1931 meeting of the International Geographical Congress (The Correlation of Ancient Marine Levels, *Comptes Rendus Congr. Internatl. de Géogr., Paris, 1931*, Vol. 2, Part 1, Paris, 1933, pp. 42–54).

GEOGRAPHICAL REVIEWS

Soils of the United States

C. F. Marbut. **Atlas of American Agriculture: Part III, Soils of the United States.** 98 pp.; maps, diagrs., ills., bibliogrs. U. S. Dept. of Agriculture, Washington, 1935. $5.00. 19 x 14 inches.

In the soil-survey work that was started in the United States in 1899 more than 5000 soil "types" in some 2000 series have been discovered, described, and plotted on maps published on the scale of one mile to the inch. Additional great areas have been mapped on the scale of two miles or four miles to the inch, most of the farmed lands of the country having been covered by these studies. The surveys, with their maps and descriptive texts, form excellent basic material for studies of relatively small units, but for geographers, economists, and planning experts they lack broad regional expressions. The broader characteristics are lost in the maze of detail. In compiling the map now published in the "Atlas of American Agriculture" Dr. Marbut took a long step toward a broader grouping based on soil characteristics. After his study of the work of the Russian pedologists Dr. Marbut endeavored to interpret the soils of the United States on the basis of their classifications, but this did not prove wholly successful, and in the Foreword of the present publication he states: "No two continents of the world are identical. Principles worked out on the basis of conditions in one continent cannot be applied without modification in any other. Although the report and map presented here have been constructed through an interpretation of American soil facts in terms of general principles of pedological science, adjustments have been made to fit special conditions."

The large soil map (12 sheets, scale 1 : 2,250,000) shows 243 groups of related soil series. In the master legend these have been placed in nine divisions, Podzol Soils, Gray-Brown Podzolic Soils, Red and Yellow Soils, Prairie Soils, Chernozem Soils, Dark-Brown Soils, Brown Soils, Gray Desert Soils, and Undifferentiated (materials), and in the selection of colors for the map these broad relationships were kept in mind. When the 12 sheets are assembled in one large map, these relationships and the geographic distribution of the soil groups become apparent, though in many areas a very involved pattern is shown.

The text includes a general discussion of soil classification, essentially following the outlines presented by Dr. Marbut before the First International Congress of Soil Science (Washington, D. C., 1927). A presentation of the soil series as a basic category is followed by the discussion of the series and groups of soil series under the broad headings named above.

The Podzol soils lie mainly in New England and the northern part of the Great Lakes states, with outliers in Pennsylvania and the western mountains. They show a rather well defined geographic distribution, with a close relation to climate and forest cover.

The Gray-Brown Podzolic soils appear to be a very broad and poorly defined group into which were placed all soils that did not fit elsewhere. The heterogeneous inclusiveness shown on the map is not, however, carried out in the text, in which these soils east of the Great Plains region are described under 13 headings, each having a more or less definite geographic distribution, and the discussion of the Gray-Brown Podzolic soils of the West is included under the geographic headings of "The Soils of Eastern Washington and Oregon" and "Soils of the Pacific Coast." A study of the distribution of color on the assembled map suggests that the soils in this category could be segregated in several less inclusive groupings that would be more definite in their pedological characteristics and more distinctly geographic in their distribution. The Brown soils, or *Braunerden* of Europe, have not been recognized in this classifica-

tion; some of the soil groups included in the Gray-Brown soils might prove to be better placed in a Brown-soil category.

The Red and Yellow soils include primarily the soils of the Atlantic and Gulf coastal plains and of the Piedmont plateau and some soils of the Mississippi Valley and the Pacific coast. The assembled map suggests further subdivisions, whose boundaries might follow rather closely those of the soil-province map (*U. S. Dept. of Agric. Bur. of Soils Bull. No. 96*, 1913).

The soils of the other groups, Prairie soils (a group not as yet found in other parts of the world), Chernozem soils, Dark-Brown soils, Brown soils (not at all like the *Braunerden* of Europe), and Gray desert soils, show definite geographic distribution, though the last three are rather badly cut up by areas of "Rough and Stony land" on the mountains of the West; and they also occur in very mixed associations, particularly along their rather indefinite boundaries.

The soils of the Pacific coast, although included in the map legend with the soils of the 9 large groups or divisions, are described separately. Dr. Marbut says that "because of the rapid changes in relief from place to place, the dynamic factors of climate and natural vegetation are not distributed uniformly over large areas. All gradations or combinations of climate and natural vegetation occur within a comparatively short distance. . . . All the great soil groups which occur in the eastern part of the United States occur also in the Pacific coast region, but in no case do these great groups occur in areas large enough to make it possible to show their distribution on the soil province map. The Pacific coast region constitutes a region of its own, one may almost say a world of its own, and it is more convenient to discuss it as a separate geographic region than to discuss its soils as members of the great soil groups."

In addition to the large-scale map there are four maps on the scale of 1: 8,000,000, showing the "Areas Covered by the Soil Survey," the "Distribution of the Great Soil Groups," the "Distribution of Parent Materials of Soils," and the "Distribution of Soils without Normal Profiles." There is also a detailed soil map of Clarke County, Georgia, on the scale of 1 mile to the inch. Other plates show the colors of 23 series profiles and the mechanical and chemical composition of representative series from the eight soil groups. The publication is illustrated with numerous photographs of soil profiles and of landscapes characteristic of the series and soil groups. It contains many tables of physical and chemical composition of selected soil profiles and brief statements of the methods followed in these analyses.

From the pedologist's viewpoint, this work emphasizes not only the soil relationships that are definite and distinctive but also the need for further study to determine broader relationships and to outline areas of soils having commoner characteristics. The large soil map is an excellent foundation for such studies, and the distribution of colors suggests that there are relationships other than those indicated either by the grouping in the legend, on the small-scale soil-group map, or on the early soil-province maps. Perhaps the geographers who are not handicapped with detailed soil information may contribute to the solution of the regional soil distribution. Dr. Marbut's map should give them suggestions for such regionalization. The work is distinctly Dr. Marbut's. He has freely used basic material from all sources but primarily, of course, from the Soil Survey Division of the Bureau of Chemistry and Soils, which he so long directed. Most of the detail on the map between the Rocky Mountains and the Sierra Nevada and Cascade ranges is based on observations or unpublished reconnaissance surveys by the author or members of his staff, since this region has very few detailed soil-survey areas. This contribution to soil science cannot be realized without much more research into the common characteristics of the 243 soil groups shown on the map.

"Soils of the United States" constitutes one of the most valuable contributions to the study of soils that have been made in many years. It stands as a challenge

to the pedologists who may have the privilege of carrying forward the work that is so well begun. Its publication is a fitting climax to the work of Dr. Marbut as the leading American pedologist.

CHARLES F. SHAW

LOS ANGELES

ANTON WAGNER. **Los Angeles: Werden, Leben und Gestalt der Zweimillionenstadt in Südkalifornien.** xii and 295 pp.; maps, ills., bibliogr. Bibliographisches Institut, Leipzig, 1935. RM. 9.50. 10 x 7 inches.

Modern German methods of the study of settlement, applied to one of the most geographically unstable of American cities, make Dr. Wagner's work a pioneer in its field. In addition to the usual descriptions of natural and cultural landscapes before the influx of white settlers, of the growth of the city, and of the present urban landscape with its people and economic life, the author includes classifications of settlement types, house types, street patterns, place names, and other cultural items not usually included in urban studies made by American geographers. As an application of method alone, therefore, the work is outstanding, though better results might have been obtained had the author selected a city of different aspect.

The book deals with the Los Angeles metropolitan district. Phases of the subject have been studied before, but this is the first attempt at comprehensive geographical synthesis, and in view of the field work alone, in itself a major problem, the results obtained are as satisfactory as might be expected in a work that necessarily excludes the presentation of many details. For instance, although the author recognizes the natural approaches to Los Angeles, he neglects to give adequate information concerning their locations and the functions of different corridors in the region.

In his discussion of the growth of Los Angeles, Dr. Wagner retains the term "boom," for its full significance and its implications in American urban growth are so peculiar that adequate translation is difficult. Three boom periods are indicated: the first in 1886–1888; the second from 1902 to 1914; and the third, since 1922. The first period resulted in increase of population and the establishment of subdivision cities "on paper." It was a genuine land fever; but to place it in the same category as succeeding periods, when growth of the city took place because of rapid extension of electric railways, building of the aqueduct, or increase of automobile transportation, is unsatisfactory. Certainly the second and third booms lacked some of the more flagrant speculation of 1888, though at no time were land frauds entirely curbed. The chapter dealing with the urban landscape fails to convey a clear-cut idea of the modern Los Angeles; for the material on the harbor, the film industry, and the oil fever is poorly coördinated, and it is only by reading between the lines that their relationships to the various "booms" are clear. The short chapter on modern commerce and the port is a confused mixture of undigested and unrelated briefs.

Probably the most important geographical contribution is contained in the chapter on settlements, especially since the effect of the Ord plan for the city is studied in relation to the site. Street patterns of Los Angeles and San Francisco, similar in plan, are compared effectively in regard to the problems of local transportation that they have created.

Geographers and tourists alike may be attracted by the singularities of a city landscape. Banana plants in the courtyard of the "typical Normandy village" and other anomalies have impressed the exotic character of Hollywood on the author. To the Los Angeles resident, however, these things seldom appear incongruous. Odd place names, combining different languages, or entirely meaningless in themselves, are as commonplace in Los Angeles as are the "classical" cities—Rome, Utica, Syracuse, Carthage—in central New York. Such names are a matter of style, and too much significance should not attach to them.

The urban instability of Los Angeles made this book out of date before it came

from the press. For example, Plate 24, showing the Chinese quarter of the city, reproduces a section that has already been cleared of occupants and buildings in preparation for the construction of the new railroad station. No geography of this city could be entirely up to date, for change is taking place too rapidly.

There are many maps scattered through the text, but they are not always effective, and some of them are misleading. Map 5, the city plan of 1857, and Figure 9, the landholdings of the Indiana Colony (Pasadena), fail to indicate compass directions. Map 4, the present street pattern, should show the Santa Monica Mountains and other relief features to account for the lack of streets in parts of the city. The book has no index, but a very long bibliography is appended.

H. F. RAUP

A REGIONAL STUDY OF NORTH CENTRAL ENGLAND

WALENTY WINID. **Anglja między 1° a 3° dł. Zach. Gr. i 53° a 54° szer. Pn. (England between Latitudes 1° and 3° W. and Longitudes 53° and 54° N.).** 192 pp.; maps, diagrs., ills., bibliogr. *Études Géogr.: Trav. de l'Inst. Géogr. d'Univ. à Poznań, No. 9–11.* S. A. Książnica-Atlas, Poznań, 1934. 10 x 7 inches.

This is an interesting regional study of part of England by one of the younger members of the vigorous school of geographers now at work in Poland. The text is in Polish; but the legend to each of the 33 illustrations and a full summary are given in a rather foreign English.

The area described includes the southern part of the Pennine highland and the industrial regions surrounding it to the west, south, and east. Dr. Winid presented to the International Geographical Congress at Warsaw in 1934 two papers, "The Problem of Geographical Laws Governing the Distribution of Industries" and "The Scope of Urban Geography"; this study may be regarded as a base for the views stated in more general terms in those papers.

In his summary the author lists no less than 17 "peculiar characteristics" of the region, of which perhaps the chief are (1) the close juxtaposition of considerable areas of maximum world density of population to uninhabited highland and to some very thinly peopled tracts of lowland and (2) the high degree of urbanization (less than 5 per cent of the population is rural). In reckoning the number of towns he follows the census figures, and so with the municipal boundaries, and thus he counts the West Yorkshire conurbation as five large and many small towns. Yet in his description of the landscapes he stresses the view that "any town considered geographically is an island in a rural sea" and there regards each group, which he calls a "town-constellation," as one town. Apparently he has not considered the studies of the British conurbations made in England (see, for example, C. B. Fawcett: Distribution of the Urban Population in Great Britain, 1931, *Geogr. Journ.*, Vol. 79, 1932, pp. 100–116). Also his maps seem to understate the extent to which "ribbon building" along the many new or improved highways has linked the towns together. The Ordnance Survey did not begin to publish the sheets of the postwar revision of its one-inch maps of this area until 1935; and the author has been mainly dependent on maps published before the new roads due to the increasing use of automobiles came into existence.

Dr. Winid notes that the large towns are on the borders of the active coalfields; and, after a brief reference to other areas, he adds the general assertion that "on coalfields there are no important cities" (p. 155). It is true that in this region the coalfield now active is just east of the industrial towns of Yorkshire and Nottinghamshire, but many of these towns grew up on what was once the active coalfield, though the mines in them are now exhausted; and there are large mines still working within the municipal limits of Leeds and Nottingham and several smaller towns. As a correction of the opinion, still often expressed, that large cities naturally develop

on coalfields the author's assertion may be useful; but it seems to err in the opposite direction.

Dr. Winid also denies the commonly accepted views regarding regional specialization of industries in this area. His opinion is that manufacturing industries are gregarious (p. 155): this may be associated with his statement (p. 162) that "as mining exploits mineral deposits, so industries exploit human deposits," an expression of the fact that industries tend to follow population. Nevertheless, there is a high degree of regional specialization. The Nottingham district contains 100 per cent of the employed machine-lace workers of Great Britain, though lacemaking is not now its principal industry. The West Yorkshire "Woollens District" contains 84 per cent of the registered workers in woolen manufacture.

The agriculture is described as "barbaric," a condition that the author ascribes in part to the concentration of human energy on other industries. But his description omits at least three important circumstances: the shortness of the growing season, the general poverty of the soil, and the fact that from about 1850 to 1930 Great Britain was a free-trade country and its agriculture was exposed to the full force of competition from the newer lands after about 1875. An account of British agriculture that overlooks this factor is incomplete. The total omission of this external factor is in harmony with the purely geographical and objective description that Dr. Winid has undertaken; but it serves to remind us that geographical facts alone cannot give a complete explanation of many human distributions.

Dr. Winid's study is notable for its original diagrams, many of which express the results of careful and laborious calculations and deserve careful study for their method as well as for the facts represented. Methodical quantitative analysis of this kind is necessary as the base for any sound theorizing, especially in human geography.

As a whole Dr. Winid's work is a valuable example of the method of objective description in human geography applied to a very complex area. It leads us to look forward with great interest to his forthcoming book on "The Urbanization of Poland, England, and the United States."

C. B. FAWCETT

A HISTORICAL GEOGRAPHY OF THE RUHR REGION

HANS SPETHMANN. **Das Ruhrgebiet im Wechselspiel von Land und Leuten, Wirtschaft, Technik und Politik.** Vol. 1, **Von der Vorrömerzeit bis zur Gestaltung eines Reviers in der Mitte des 19. Jahrhunderts**; Vol. 2, **Die Entwicklung zum Grossrevier seit Mitte des 19. Jahrhunderts.** Vol. 1, 252 pp.; Vol. 2, pp. 253–676; maps, ills., bibliogr. Reimar Hobbing, Berlin, 1933. 10 x 7 inches.

"To show the landscape development of the Ruhr district up to our time"—in other words, "to show how that which is visible to us as the Ruhr district has developed and lives today"—is the stated purpose of these two large volumes (the present structure will be described in two following volumes). The first two volumes, then, constitute a historical geography in which the landscape of the area is depicted in twelve historical "cross sections," beginning with the almost unbroken forest land of the pre-Roman time. The first five, before the development of modern industry, are briefly dealt with; those since the end of the eighteenth century take up about four-fifths of the total work. The abstract at the beginning of each chapter, with page references, will be greatly appreciated by the reader who wishes to get a summary picture of each period or who wishes to find detailed discussion of particular points. The expositions of the "cross section" are developed in a wealth of textual detail based on an extensive bibliography systematically arranged at the end of Volume 2 (footnote references are not used) and some 190 well selected photographs, old drawings, and—most valuable—old maps of individual cities and

their environs. The illustrations are beautifully reproduced and add greatly to the attractiveness of the volumes. Unfortunately, except for some railroad nets, there are few maps to show the development of the landscape or any of its features at the different periods—maps such as those so effectively used in the "Saar-Atlas" (see review in *Geogr. Rev.*, Vol. 24, 1934, pp. 680–682) to show population, mines, industries, forests, etc. For a study in historical regional geography (*dynamische Länderkunde*) such as this is intended to be, no amount of verbal description can replace maps of this kind.

In explaining the changes shown between the different periods the author attaches great importance to the work of individual industrialists. Although no one can question his theory, worked out at considerable length, that the present landscape of the Ruhr is no inevitable result of natural factors but predominantly the work of man, little evidence is presented to show that it would have been very different in any important respect if the dozen or so individuals discussed in detail—Krupp, Kirdorf, Stinnes, etc.—had never lived. One may well believe that without Zeiss Jena would have been very different today; that Essen, if Krupp had not started there, would have had little reason for becoming the chief center of the Ruhr. Nevertheless, given the general industrial development of Western Europe and the discoveries and inventions of such men as Bessemer, Siemens, Martin, and Thomas —whom the author treats as of less importance—it is hardly conceivable that the Ruhr region, with its enormously rich coal deposits located so close to the Rhine and to the sea, would not have been developed by one group or another into something much like that which it is today. For his a priori theory to the contrary the author presents no evidence.

That the part played by the several million workers is taken entirely for granted is a negative symptom of Spethmann's marked prejudice against the labor movement, which expresses itself all too positively in the final section, dealing with the war and postwar periods. Here the author obviously gets so lost in the political conflicts introduced by the war and the Franco-Belgian occupation that he neglects to show whether these resulted in any changes in the present landscape.

In a kind of appendix chapter Spethmann summarizes the principles underlying his method of work. This forms an interesting discussion of methods in regional geography, though unfortunately it degenerates at the end into an exposé of personal conflicts. Although one wishes that Spethmann had made more use of the geographer's special technique—presentation on maps—and that he had been more ruthless with blue pencil and scissors, these two volumes are rich in valuable material, and we look forward to the completion of this work on the Ruhr.

RICHARD HARTSHORNE

ARID LANDFORMS

J. T. JUTSON. **The Physiography (Geomorphology) of Western Australia.** 2nd edition, revised. xvi and 366 pp.; maps, diagrs., ills., bibliogr., index. *Western Australia Geol. Survey Bull. No. 95*, 1934.

The book is divided into 16 parts, of which the first five deal with primary factors such as climate and geology and their bearing on the morphology. Part 6 deals with the nine physiographic regions recognized. Special discussions follow dealing with the river systems, the Great Plateau, Salinaland, the sunklands, soaks, and rock weathering. Mr. Jutson is the foremost authority on the details of the topography of the enormous southern salt-lake region to which he has given the name "Salinaland."

He adopts De Martonne's classes of exoreic, endoreic, and areic for his three primary divisions. He places the rivers of Pilbaraland and Murchisonia in the exoreic area, though they may cease flowing for years and might fairly be placed

in the areic region. The same objection holds true for Salinaland and Sandland, which he groups in the endoreic area. The reviewer sees no reason for departing so far from De Martonne's own deductions for this area (Regions of Interior-Basin Drainage, *Geogr. Rev.*, Vol. 17, 1927, pp. 397–414).

In the chapter on the physiographic divisions each region is illustrated by numerous typical photographs, by orographic maps, and by brief discussions of the economic aspects. The reviewer is glad to find that his suggestion of the name "Swanland" is adopted for the southwest corner, the most valuable part of this huge state of a million square miles. The views of D. W. Johnson on the scarp behind Perth are discussed in some detail, and the later work in the Swan region of Woolnough, Somerville, and others is incorporated.

The evolution of the dry lakes in Salinaland is one of the most interesting problems in Australian morphology. There are a score of these playas averaging about 50 miles in length as well as countless smaller ones. They have been described as the remains of a former sea, as interrupted river channels, and as due to deformation of the peneplain. Jutson describes their erosion as mainly due to wind and gives further evidence that they are migrating eastward. There is an interesting discussion of the "breakaways," which are mesalike structures of decomposed granite, representing the residuals of a former peneplain surface. Often the process of erosion is complicated by the presence of a hard cap of laterite. In most cases "pockets" develop in the capping, these widen to gullies, the harder crust is undercut owing mainly to wind erosion, and finally the mesa vanishes entirely. The enormous area of Sandland contains dunes, which are mostly fixed by spinifex and other desert plants. But the tops of the flat, broad dunes move westward, and off the Wollal coast the reviewer has seen (from the air) enormous areas of fine sand floating on the sea, just as occurs to the lee of the Sahara.

Jutson's discussion of the origin of the great peneplain of Australia supports the general opinion that peneplanation by normal erosion occurred in early-Tertiary time. Elevation to a height of about 1200 feet took place mainly in Pliocene time, but the climate has become arid since peneplanation occurred.

There are five large folded maps of parts of Western Australia at the end of the volume. A curious omission is that of the 10-inch isohyet on the useful vegetation map, though it is shown correctly on page 9. This valuable discussion of arid topographies closes with a bibliography of nearly 200 entries.

GRIFFITH TAYLOR

THE RAINFALL OF THE ARGENTINE REPUBLIC

El régimen pluviométrico de la República Argentina. 28 pp.; maps, diagrs. *República Argentina, Ministerio de Agric., Direccion de Meteorol., Geofisica e Hidrol., Ser. F, Publ. No. 1*. Buenos Aires, 1934. 12½ x 10½ inches.

This work is a remarkable publication for South America because of its unusual abundance of observed data, based on the records of no fewer than 868 stations. For each of these the mean monthly and mean annual precipitation of the 15 years 1913–1927 are printed.

A study of 6 stations where records cover 40 years suggests that the differences between the averages for the last 15 years and those of the 40 years are never more than 8 per cent and most of them probably not more than 5 per cent. The 40-year records also show that the last 15 years were somewhat wetter than the previous 25 in most of the Republic; but at Tucumán in the northwest they were a trifle drier. For the city of Córdoba the amounts of rain measured each month from 1888 to 1927 are given.

"It is evident at a glance that the annual precipitation decreases from the coast toward the interior in the region north of Patagonia. There is, however, an excep-

tion for the province of Tucumán and adjacent zones in the north and west, where the rainfall in abundance and in proportion is strikingly greater than in regions around." This is an excellent résumé of the facts shown on the 17 maps (1 : 7,000,000) that illustrate the paper.

It is perhaps appropriate in a geographical journal to emphasize the interest of nonmeteorologists in the study of distribution of rainfall, which centers of course in its consequences for life. Although the present work was not possible until earnest men had founded the excellent net of stations and made the long series of observations on which these maps of isohyetals are based, there is little in the statement quoted that has not long been known to intelligent Argentines who are not meteorologists. Men may maintain life at rainless places like Coolgardie as long as a gold output or some other exceptional source of wealth enables them to pay the cost of water pipes hundreds of miles long, but permanent settlement is closely adjusted to possibilities of plant life that only rainfall can maintain. Irrigation creates no water supply but merely saves and distributes rainfall advantageously.

Most rainfall maps of South America have not been so helpful to an understanding of life there as they should have been. In 1921 the writer pointed out this failure for Chile in his "Rainfall of Chile" (*Amer. Geogr. Soc. Research Ser. No. 7*).

The great economic resource of Tucumán is sugar, which can be raised there only because of the island of heavier rainfall. This has been well known to Tucumán planters these forty years but has not been clearly represented on current rain maps. For instance, try to find it on Knoch's map (Klimakunde von Südamerika, 1930, p. 76) or on the map in Denis's fascinating "Amérique du Sud." It is no defense to say that the maps cited are of very small scale, 1 : 54,000,000 and 1 : 45,000,000 respectively. For if these small scales prevented the maps from showing what a rain map is supposed to show, why were they not made larger? From Denis's map one would infer a matter of 400 millimeters of rain at Tucumán instead of the 800 and 900—at the Ingenio Santa Ana 1084—that actually fall there. There is a pressing need of larger and better rain maps. Apparently the often determining character of this element in human environment is not thoroughly appreciated.

The driest part of the Republic is in San Juan and La Rioja provinces just east of the Andes. Four stations there each record less than 100 millimeters a year. Jujuy, Salta, Catamarca, and La Rioja, all in the northwest, have stations where no rain at all fell in one or more months for the 15 years.

Special attention is called to the maps of annual, summer, and winter rainfall: they constitute a great addition to our knowledge of Argentine geography.

MARK JEFFERSON

A BOTANIST'S STUDY IN GLACIAL GEOLOGY

WILLIAM S. COOPER. **The History of the Upper Mississippi River in Late Wisconsin and Postglacial Time.** xii and 116 pp.; maps, diagrs., ills., bibliogr., index. *Minnesota Geol. Survey Bull. 26.* The University of Minnesota Press, Minneapolis, 1935. $4.00. 9 x 6 inches.

It has long been known that extensive segments of the present Missouri and Ohio rivers were localized by margins of the Pleistocene ice sheets, and it has recently been suggested that the Mississippi River across the Driftless Area may have so originated. Dr. Cooper's intensive study now brings out a similar origin for the Mississippi from its source to Minneapolis, a region in which bedrock is rarely exposed and the river flows almost entirely on drift. A part of the present drainage came into existence during the Patrician ("Middle Wisconsin") glaciation, as runoff between accumulations of end moraine and the margin of the waning ice. This condition was repeated during the Late Wisconsin glaciation, when another considerable segment of the

river, augmented by meltwater, migrated laterally with the shrinking ice margin until it reached rising ground, at the base of which it became incised in its present route. During both deglaciations the development of the drainage was complicated by the presence of much stagnant ice, some of which, buried beneath stratified drift, seems to have persisted from the Patrician glaciation into the Late Wisconsin. The wasting of stagnant masses of ice resulted in the development of numerous kettles, some of them very large. Filling and erosional breaching have since destroyed many of these depressions.

Dr. Cooper gives an excellent picture of conditions during deterioration of the ice, describing the drainage as having "skirted the ice edge as a glacial river of great size, which wore back the margin at a rapid rate. Often it encountered gaps in the continuity of the disintegrating ice sheet, and portions of its waters flowed through them, accelerating its disappearance and building up sedimentary deposits en route. With continued thinning of the ice, the waters came to flow in places over its surface, burying extensive masses beneath a load of sand and gravel. During the process great expanses must have appeared as a chaotic maze of ice blocks, sediment-laden watercourses, and unstable sand flats."

Although but little incised below the profile of its own outwash deposits, the Mississippi exhibits two postglacial terraces, each graded to the Minnesota River, which was the master stream at that time.

Special attention is devoted to "Lake Grantsburg," a broad, shallow lake dammed by a lobe of the Late Wisconsin ice and now recorded by a somewhat patchy veneer of lacustrine silt. Like many other temporary glacial lakes of smaller size than the Great Lakes, it has left no strand lines by which its water-surface plane can be accurately restored. A broad accumulation of outwash sand, the Anoka sand plain, is also treated in detail because of its earlier interpretation as dune sand. Here the criteria for discriminating between fluvial and eolian sand are critically considered.

Groups of dunes occur on the outwash as complexes of overlapping sand waves; they are up to 100 feet in height, and their lee slopes reach the remarkable maximum steepness of 40° to 45°, apparently through the aid of vegetation during accumulation of the sand. The sand was blown from the local outwash by southwest winds, which selected predominantly the finer fractions for deflation, as a comparison of mechanical analyses of outwash and dune sand clearly shows. Dr. Cooper believes that the immediate cause of deflation was lowering of the water table attendant on the postglacial incision of the Mississippi mentioned above and that vegetation had probably become established before deflation. This is interesting in view of the frequent assumption by geologists that the Pleistocene loess and other eolian deposits are chiefly attributable to the episodes (if any) between glacial uncovering and vegetational encroachment.

RICHARD FOSTER FLINT

NORTHEASTERN AMERICA BEFORE THE SEVENTEENTH CENTURY

CHARLES KNOWLES BOLTON. **Terra Nova: The Northeast Coast of America before 1602: Annals of Vinland, Markland, Estotiland, Drogeo, Baccalaos, and Norumbega.** xiii and 194 pp.; maps, ills., index. (Useful Reference Ser., No. 56.) F. W. Faxon Co., Boston, 1935. $3.50. 8½ x 6 inches.

It is, of course, difficult to give within a space of less than two hundred pages a satisfactory account of what happened in the northeastern part of the western hemisphere from the earliest times down to the year 1602. This, however, is the task undertaken by the author of the book under review, a volume in the "Useful Reference Series." Parts of it are too scrappy, other parts too diffuse, to serve the purpose implied in the series title; it does not concentrate on the most important points or build upon the best authorities. The author does not apply a very critical

method in his presentation and dwells, often unduly, on unimportant or questionable matters; the story of the Norse discoveries, for instance, is not well presented. The author's imagination sometimes leads him astray, as when he suggests that Gudrid "the Norse Skraeling" may have been the first discoverer of the American continent: she is, however, no other than the apparition that appeared under that name to Karlsefne's wife during the fight between the explorers and the natives. More than once he mentions a voyage of a ship from Lübeck to the vicinity of Newfoundland in the year 1353 as if it were a historical fact, yet the only authority for it seems to be a Portuguese source of about 1560. Nor does he apparently have any doubt concerning the alleged Danish-Portuguese expedition of about 1470, which certainly is questionable in many respects. On the other hand, it is to his credit that, although reluctantly, he declines to accept the Kensington runic inscription as genuine. The most useful part of the book for reference purposes is the last section, which contains an alphabetical list of "Several Persons Reputed to Have Been on the North East Coast before 1602." It is commendable that the author does not include in this list the names of the Zeni, though in the text he seems to credit their story, or at least parts of it.

HALLDÓR HERMANNSSON

EARLY PORTUGUESE NAVIGATORS

EDGAR PRESTAGE. **The Portuguese Pioneers.** xiv and 352 pp.; maps, index. (The Pioneer Histories.) A. & C. Black Ltd., London; The Macmillan Company, New York, 1933. $4.00. 9 x 6 inches.

GOMES EANNES DE AZURARA. **Chroniques: La conquête de Ceuta; La découverte de la Guinée.** xiv and 200 pp.; map, ills. (Les grands navigateurs et colons portugais du XVe et du XVIe siècles.) Éditions Duchartre, Paris, 1934. 8½ x 6½ inches.

It is now nearly seventy years since R. H. Major published "The Life of Prince Henry of Portugal, Surnamed the Navigator; and Its Results." Although his researches have been followed up and supplemented by numerous scholars of the English-speaking world, notably Henry Harrisse, E. G. Ravenstein, H. P. Biggar, and Sir Raymond Beazley, the chief contributions in recent years to our knowledge of the subject of Portuguese overseas expansion have been made by Portuguese. Unfortunately the work of these men has been slow to win general recognition, in part because of the language barrier. We welcome, therefore, Professor Prestage's latest work; for in "The Portuguese Pioneers" we have an up-to-date account of this early enterprise. It is somewhat smaller in compass than Major's work, but it contains much material that was then and still later unknown; it makes full use, for instance, of Joaquim Bensaude's work on the origins and development of nautical science in the Iberian Peninsula and of Jaime Cortesão's thesis concerning the alleged Portuguese conspiracy of silence in the fifteenth and sixteenth centuries. But Professor Prestage is himself a Portuguese scholar of the highest rank, and in addition to giving us the fruits of other people's labors he gives us his own interpretation of the causes of the enterprise and its course from the expedition to Ceuta in 1415 down to the settlement of Macao in 1557. His failure to go as deeply as we might have wished into the controversies of the period, e.g. the possibility of a pre-Cabralian discovery of Brazil, is to be excused on the ground that his aim is "to provide a broad survey of a great migration." This he has done most admirably.

For the first thirty years of this story Azurara is practically our sole contemporary authority. His "Chronicles" of Ceuta and Guinea, the latter of which was edited and translated for the Hakluyt Society (1896 and 1899) by Sir Raymond Beazley and Professor Prestage, have now been published in a French anthology of the work of "Les grands navigateurs et colons portugais du XVe et du XVIe siècles."

The editor's aim seemingly has been to popularize these works, for she has considerably abridged the texts, dispensed with an index, and written only a very economical introduction. However, the French reader will find the footnotes a great help.

GEORGE H. T. KIMBLE

THE GEOGRAPHY OF THE ODYSSEY

RICHARD HENNIG. **Die Geographie des homerischen Epos: Eine Studie über die erdkundlichen Elemente der Odyssee.** vi and 102 pp.; index. (Neue Wege zur Antike, Ser. 1, No. 10.) B. G. Teubner, Leipzig and Berlin, 1934. 9½ x 6½ inches.

This study approaches certain problems of the Odyssey from the geographer's viewpoint. The author maintains that Homer, like all other poets and romancers, sought to lend reality to his fiction by adhering as closely as possible to known or reported fact respecting the places visited by his hero. Accordingly the author accepts seriously the data furnished by the poet and seeks to identify the localities described, taking account of the indications of the voyage and our present knowledge, geographical and archeological (see also "Geography of the Odyssey," *Geogr. Rev.*, Vol. 18, 1928, pp. 157–158). Since the wanderings of Odysseus led him westward, the author inevitably falls back on the hypothesis that much of the information regarding the western Mediterranean and the ocean was derived from the Phoenicians. Although this is an assumption, it is reasonable and can be supported by many considerations not mentioned by Dr. Hennig. A difficulty that the author does not squarely face is that the date of the Odyssey is left extremely vague, no doubt because as a geographer Dr. Hennig hesitates to pronounce judgment on a subject that primarily concerns the philologist. Some of his identifications seem rather fanciful. The Lotus Eaters are placed on the island of Meninx in the Lesser Syrtis; Aeolus dwelt on Volcano, and Polyphemus on Etna; Scylla and Charybdis are at the Strait of Gibraltar, Scylla being a huge octopus; Ogygia is an island in the outer ocean; the Phaeacians dwelt at Tartessus; and the Ithaca of Odysseus was Corfu.

W. A. HEIDEL

THE RACES OF MANKIND

HANS WEINERT. **Die Rassen der Menschheit.** vi and 139 pp.; maps, diagrs., ills., bibliogr., index. B. G. Teubner, Leipzig and Berlin, 1935. RM. 4.60. 9 x 6 inches.

This book by Professor Weinert of Berlin opens with a discussion of man's relation to the apes. Interesting diagrams of skulls, hearts, kidneys, and teeth show that man is nearer to the chimpanzees than to the other three apes. A chapter dealing with the racial tree accepts the Australian aboriginal as the living representative of early man. Three main races are distinguished, Nordic, Mongolian, and Negro, the Nordic probably being in most direct line with the Australian. It is interesting to the reviewer to find this alliance, in which he himself believes. But, as readers of this journal may remember, the reviewer in 1919 placed the Australians and Nordics (and Mediterraneans) in a group that evolved later than the Negroes but earlier than the Mongolians and allied Alpine broadheads (Climatic Cycles and Evolution, *Geogr. Rev.*, Vol. 8, 1919, pp. 289–328).

Chapters dealing with the Australians, Veddas, Melanesians, and Pygmies follow, each illustrated with excellent photographs. The Ainus are linked with the stocks of Europe; but the western invaders of Siberia and India are represented as "Indo-Germans" in Figure 63, a name that seems likely to increase the confusion between race and language. The author points out that in America the blood groups

of the Amerinds are markedly non-Mongolian. Indeed, this discussion of the debatable relation of blood groups to race is of much interest (see Allison Davis: The Distribution of the Blood-Groups and Its Bearing on the Concept of Race, *Sociol. Rev.*, Vol. 27, 1935, pp. 19–34 and 183–200). Weinert's data for the four blood groups have been collated by the reviewer and are approximately tabulated below.

Race	Per Cent in Blood Group			
	O	A	B	AB
Negro	42	24	28	6
Nordic*	40	43	12	5
Ainu*	37	24	33	5
Northern Indian* (Asia)	31	22	40	7
Gypsy* (Europe)	31	25	33	7
Mongol	20–38	24–35	24–35	7–1
Amerind	78	20	2	0
Australian	55	39	few	few

*Akin to the Mediterranean race.

The wide variation of the so-called Mongol race would seem to indicate that the classes included as Mongol need considerable revision. The close alliance between the Gypsy and the Northern Indian was to be expected. It may be noted that there is a progressive variation in blood group O from Negro through Mediterranean to Mongol. This agrees with the similar variation for hair and head breadth as used in 1919 by the reviewer in the "zones and strata" classification (*op. cit.*, p. 306). The extreme position of the Amerinds and Australians is unexpected. Possibly the Lagide stock in America, which Eickstedt and the reviewer have linked with the Australians, is more widespread than was hitherto supposed.

Griffith Taylor

Two Books on Modern Meteorology

Some Problems of Modern Meteorology: A Series of Papers by Various Authors Reprinted from the Quarterly Journal of the Royal Meteorological Society. v and 170 pp.; maps, diagrs., bibliogrs. Royal Meteorological Society, London, 1934. 3s. 6d. 10 x 6½ inches.

David Brunt. **Physical & Dynamical Meteorology.** xxii and 411 pp.; maps, diagrs., indexes. The Macmillan Company, New York; University Press, Cambridge, England, 1934. $7.00. 10½ x 7⅛ inches.

These two books grew up together. The editor of the *Quarterly Journal* thought it would be well to take stock and invited a number of well known British meteorologists to coöperate. Consequently from 1930 to 1934 the *Journal* carried one summary article in nearly every number. The sixteen, now assembled, constitute a survey of outstanding problems in meteorology today. Theories of the circulation of the atmosphere (E. W. Barlow) and of the origin of cyclonic depressions (D. Brunt) and anticyclones (C. E. P. Brooks) must now take into account the temperatures, pressures, and movements of the stratosphere. Meteorologists are beginning to realize the importance of the upper atmosphere to our weather by virtue of the ozone as an absorber in the lower 40 kilometers of the stratosphere (G. M. B. Dobson and A. R.

Meetham). The chief problem of weather forecasting is to obtain enough upper-air data for the daily performances (C. K. M. Douglas) and enough world-wide data, particularly from the Antarctic (E. Kidson), for seasonal foreshadowing (C. W. B. Normand). The climatic and forest history of Europe is rapidly unfolding (C. E. P. Brooks), though there are still some discrepancies to be ironed out between the indications of peat-bog successions, pollen spectra, the sequences of snail types, lake levels, and other physiographic evidences. Really important changes, between conditions 5° F. warmer than now and 5° or more colder and both wetter and drier, have undoubtedly occurred in the past 10,000 to 30,000 years with variations in the earth's relations to the sun, changes in the distribution of land and water, and possibly long swings in solar radiation. Problems of radiation (D. Brunt) and transformations of energy (D. Brunt); condensation (M. G. Bennett) and why it rains (C. K. M. Douglas); the splitting-raindrop and the atmospheric electric-field theories of thunderstorm electricity (R. A. Watson Watt); turbulence, which disconcertingly varies with the temperature (E. L. Davies and O. G. Sutton); terrestrial magnetism, especially magnetic variations of short duration (A. H. R. Goldie); meteorological acoustics (W. S. Tucker)—all are presented in enticing fashion by specialists in these subjects.

Recently appointed Professor of Meteorology in the University of London, the editor-author, himself an authority on radiation and energy transformations in the atmosphere, wrote the advanced textbook to meet the needs of postgraduate students. W. J. Humphreys' excellent "Physics of the Air," revised in 1929, was available, it is true; but there has been much progress in the last five years and a need for a more expanded treatment of that portion of theoretical meteorology relating to the physical condition of the atmosphere and its complicated motions. Professor Brunt's text not only includes these recent advances and presents dynamical meteorology with instructive fullness but also points helpfully to the limits of present knowledge and indicates along what lines further investigations may prove fruitful. The scope of the book is rather strictly limited to atmospheric processes and motions and, therefore, is far less inclusive than Humphreys'. Thus, there are no discussions of instruments, cloud forms, fog, dew, frost, thunderstorms, atmospheric electricity, meteorological optics or acoustics, or weather forecasting. After two introductory chapters presenting the essential facts of the distribution of meteorological elements over the globe and some statical and thermal relationships, Professor Brunt plunges into thermodynamics, discusses radiation at length, follows the air through its motions, general and turbulent, and concludes with an impartial summary of the modern idea of air masses, fronts, cyclones and anticyclones, and the general circulation of the atmosphere. An appendix presents nine useful tables. There are 112 illustrations, mostly diagrams. Although a reader would need to have a good knowledge of physics and higher mathematics to follow the author through many of his chapters, there is enough between the formulas to be instructive, even to the novice. The author's easy style, with which many of us were already familiar in his little book "Meteorology" (1928), makes the volume readable, even though it treats of a complicated subject.

CHARLES F. BROOKS

A MAP OF THE GREAT VICTORIA DESERT

HARRY T. BENNETT. **The Work of the Mackay Aerial Survey Expedition to Western and South Australia, 1935.** Map. *The Australian Geographer*, Vol. 2, No. 8, 1935, pp. 3–7.

The three Mackay aerial expeditions have made successive reconnaissance surveys of the Great Sandy Desert (1930), Gibson Desert (1933), and the Great Victoria Desert (1935). "In 1930 an area of just over 80,000 square miles was mapped, the

base used being Ilbpilla in the Ehrenberg Range, about 250 miles west of Alice Springs. In 1933 nearly 250,000 square miles were examined and mapped, the base used being in the Petermann Ranges, close to the Western Australian border. The area examined and mapped in 1935 lies to the north of the east-west railway line, the boundary on the north being the Musgrave and Warburton Ranges, on the west a line slightly east of Laverton (Western Australia), and on the east a line running north-west—south-east through Oodnadatta."

The results of the last-named expedition are incorporated in a map on Mercator's projection on the scale of three inches to a degree of longitude. The map was constructed from strip maps made on the survey flights, 30 in number, undertaken on radiating lines from the bases Oodnadatta and Cook in South Australia and Forrest, Rawlinna, and Laverton in Western Australia. Adjustment was made to control points along the transcontinental railway line and on Laverton and Oodnadatta. The map shows watercourses, salt pans, clay pans, vegetation, and sand ridges.

"The country in the area mapped is the worst I have seen in Australia. Seventy-five per cent of it is sand-ridge country, very heavily timbered with thick mulga, and of little use for anything. A forced landing while on this survey could not have been made, except perhaps on one of the salt lakes which were discovered. On some flights over 150 miles of timber were traversed without the hope of getting down safely in the event of trouble. The northern limit of the Nullarbor Plain is very clearly marked, for on the Plain itself there is an absence of trees. Limestone outcrops abound everywhere on the Plain, and cease suddenly as the timbered area is reached. Forced landings on the Plain would be disastrous owing to these outcrops, and also the thousands of rabbit burrows, which are to be seen everywhere."

This notice should be considered as a postscript to Professor C. T. Madigan's article, "The Australian Sand-Ridge Deserts" (in this number of the *Geographical Review*, pp. 205–227), which had gone to press before the arrival of the December, 1935, number of the *Australian Geographer*.